AERONAUTICAL ENGINEERING REVIEW

INSTITUTE OF THE AERONAUTICAL SCIENCES

NOVEMBER 1950

INDIANA UNIVERSITY
LIBRARY
NOV 13 1950

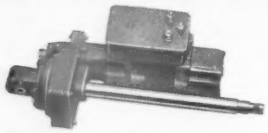
We have designs on YOUR ACTUATOR and MOTOR PROBLEMS

The exacting specifications for actuators and special motors for today's and tomorrow's aircraft pose many tough questions... but it's likely that you can find the answer through EEMCO. Our experience in designing and developing many hundreds of special types of electrical actuators and motors places at your command the "know-how" for producing units of remarkably ingenious design, compact construction, low weight, and high performance. We have the engineering personnel and facilities to handle the most difficult design and development assignments...and the manufacturing facilities to deliver the largest of orders with gratifying efficiency and speed. This is a matter of record with our many customers of note in the aircraft industry. Put one of your current problems up to EEMCO.

Typical EEMCO solutions of difficult Actuator and Motor design problems

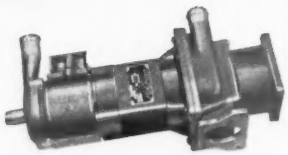
STABILIZER ACTUATOR, Linear Type

Magnetic clutch, radio noise suppressors. Normal load 2500 lbs. Maximum load, 8,000, static, 20,000 lbs. Stroke 7-1/2 in. Rate of travel, .62 inches per second. Weight, 17 lbs. Non-jamming end stops.



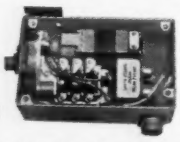
FLAP ACTUATOR, Linear Type

Magnetic clutch and brake, radio noise filter, internal non-jamming stops, auxiliary drive for manual operation. Normal load, 1800 lbs. Stroke, 5-1/2 inches. Rate of travel at normal load, .35 inches per sec. 28 volt d. c. Weight, 7-1/2 lbs.



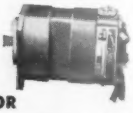
EXPLOSION-PROOF HYDRAULIC PUMP DRIVE

Equipped with inline gear reduction. Gearbox designed to keep acoustic noise level at an absolute minimum. For continuous duty operation with duty cycle varying from 1-1/2 to 5 H.P. load. Designed to operate for 2000 hours without maintenance. Operates in a vertical position. Weight, 20-1/2 lbs.



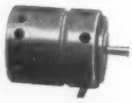
ROTARY ACTUATOR PACKAGE

Magnetic clutch and brake and gear reduction, radio noise filter, adjustable travel limit switches. Explosion-proof motor. Entire unit totally enclosed in box equipped with mounting bracket. Output RPM at 3 inch-pounds load, 2500. Weight, complete, 3-1/4 lbs.



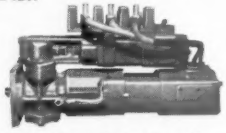
MOTOR FOR VALVE ACTUATOR

Weight, 11.7 ounces. 2-5/8" long by 1-5/8" by 1-13/16." 20 watts output at 18,000 RPM, intermittent duty. 28 volts d. c.



400 CYCLE BLOWER MOTOR

Capacitor type. Weight, 1 lb. 2-11/16" long, 2-3/8" dia. 10-1/2 watts output at 7500 RPM, continuous duty, 115 volts, single phase.

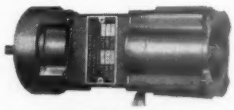


DOUBLE MOTOR POWER DRIVE

Small motor operates in conjunction with automatic pilot. Large motor used for manual control. Small motor—helical and worm gear reduction. Large motor—no reduction. *Outputs:* Small motor, 1/15 h.p. continuous; large motor, 3.3 h.p., 6 sec. duty cycle. *Output RPM:* driven by small motor, 1000; driven by large motor, 10,000. Radio noise suppressors. 26 volts d. c. Weight. 16-1/2 lbs.

1/2 HORSEPOWER EXPLOSION-PROOF MOTOR

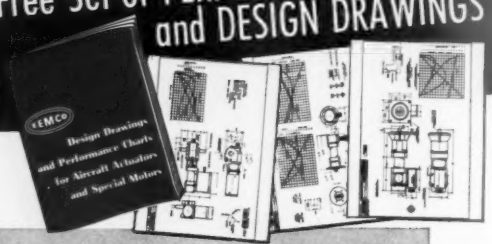
For use on a bomb hoist dolly. 24 volts d. c., 3,450 RPM, continuous duty. Weight, 17 lbs. Built to withstand exposure to the elements.



GUIDED MISSILE CONTROL MOTOR

3/4 H. P., 25,000 RPM, 10 minute duty cycle. Weight, 2.9 lbs. Silicone insulated. High temperature materials throughout. Temperature on outside of case at end of run, 250°C without damage to materials.

Free Set of PERFORMANCE CHARTS and DESIGN DRAWINGS



Performance Charts and Design Drawings for the above units, and many others, will be sent to executives and engineering and design personnel making request on company letterhead. These prints illustrate solutions of difficult design problems. They may suggest answers to similar problems of your own. Additional prints, for permanent reference file, supplied as released.

ELECTRICAL ENGINEERING and MFG. Corp.

DESIGN • DEVELOPMENT • LARGE-VOLUME MANUFACTURING

EEMCO

4612 West Jefferson Blvd.
Los Angeles 16, Calif.

Flying time-

40 years

GOODYEAR
AVIATION
PRODUCTS

Goodyear Wing tires on Wright Biplane—1910

Goodyear track landing gear on B-36

IN 1910 Goodyear organized a separate "Aeronautics Department" to handle the growing business on the Wing airplane tire—the first pneumatic tire specially designed for aircraft. This new department pioneered in the development of tubes, rims, wheels, rubber shock absorber springs, wing fabric and other needs of early airplanes built by Wright Brothers, Curtiss, Martin and others.

From this "Early Bird" beginning, Goodyear has continued to lead in meeting the changing demands of aviation—both lighter and heavier than air.

Proof of this are such notable Goodyear developments as the low-pressure tire, Multiple and Single Disc brakes, the Cross-Wind Landing Wheel, the endless belt landing gear, bullet-sealing and Pliocel fuel tanks, heated Iceguard wing and propeller boots, Airfoam cushioning and scores of other everyday necessities of modern civilian and military aircraft.

The industry's dependence upon Goodyear's experience and skill is attested by the fact that today, as for many years past, "*more aircraft land on Goodyear tires, tubes, wheels and brakes than on any other kind!*"

Goodyear, Aviation Products Division
Akron 16, Ohio or Los Angeles 54, California

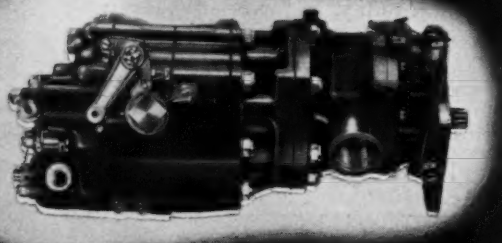
We think you'll like "THE GREATEST STORY EVER TOLD"—Every Sunday—ABC Network

Pliocel, Iceguard, Airfoam—T.M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

THE AIRCRAFT: Douglas F3D Navy Skyknight

THE ENGINE: Westinghouse J-34 Jet Engine

THE FUEL SYSTEM: Holley R-46 Turbine Control



HOLLEY

Carburetor Co.

DETROIT

FOR HALF A CENTURY—ORIGINAL EQUIPMENT MANUFACTURERS FOR THE AUTOMOTIVE AND AIRCRAFT INDUSTRIES

Cover—Production model Boeing B-47 Stratojet, powered by six General Electric J-47 turbojet engines.

Editor
Welman A. Shrader

Managing Editor
Bernelce H. Jarck

Assistant Editor
John J. Glennon

Book Reviews Editor
Maurice H. Smith

News Editor
Beverly A. Dodge

Editorial Assistant
Marylu Howell

Technical Advisers
Hugh L. Dryden
Robert R. Dexter
S. Paul Johnston

Business Manager
Joseph P. Ryan

Western Office
7660 Beverly Blvd., Los Angeles 36, Calif.

ABC

SUBSCRIPTION RATES

Aeronautical Engineering Review: United States and possessions, 1 year, $3.00; single copies, $0.50. Foreign countries including Canada (American Currency Rates), 1 year, $3.50; single copies, $0.50.

Entered as second-class matter at the Post Office, Easton, Pa., April 29, 1942. Acceptance for mailing at a Special Rate of Postage as provided for in the Act of August 24, 1912.

Publication Office: 20th & Northampton Streets, Easton, Pa.

Editorial Office: 2 East 64th Street, New York 21, N.Y. Notices of change of address should be sent to the Institute at least 30 days prior to actual change of address.

Statements and opinons expressed in the *Aeronautical Engineering Review* are to be understood as individual expressions and not those of the Institute.

Copyright, 1950, by the Institute of the Aeronautical Sciences, Inc.

AERONAUTICAL ENGINEERING REVIEW

Vol. 9 NOVEMBER, 1950 No. 11

Contents

I.A.S. News 5
Editorial 19

Articles

The Application of Pressure Refueling to Flight . . . . . George E. Woods-Humphery 20
Progress in Stall Research . . . . . Graham Campbell and Gifford Bull 24
Problems Related to Airworthiness Requirements for Commercial Turbine-Engined Airplanes . . . . . George W. Haldeman 33
Current Turboprop Power-Plant Installations . . . . . F. H. Sharp 41
I.A.S. Previews 49

Reviews

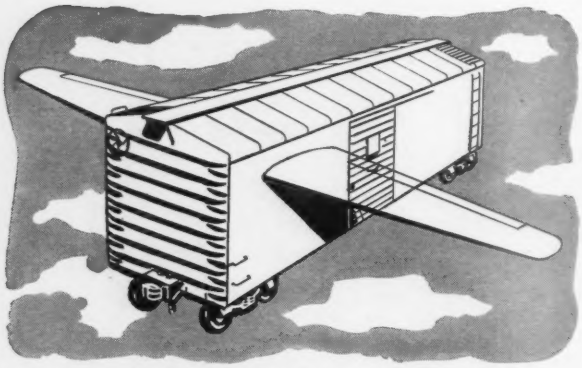
Aeronautical Reviews 57
Books 77

I.A.S. Preprints 45
Personnel Opportunities 91
Index to Advertisers 95

Published Monthly by the Institute of the Aeronautical Sciences, Inc.

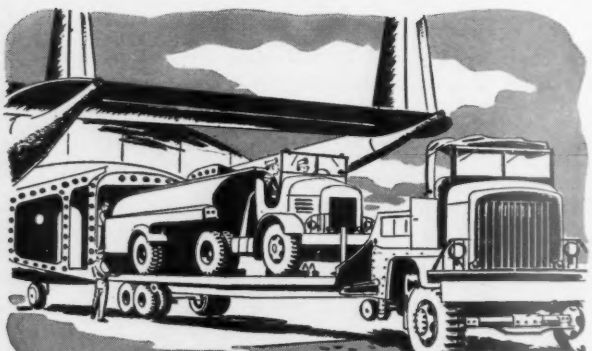
Engineered TO ORDER!

The Fairchild C-119 twin-engine cargo and troop transport was *engineered* to fill the order for a plane that can utilize small landing fields, fly long or short distances economically—carry huge loads of men, cargo and equipment under all operating conditions.

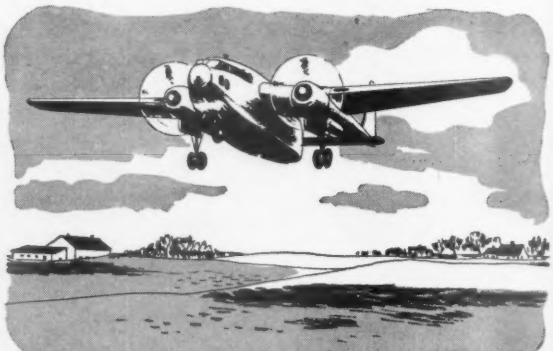


THE BOX-CAR PRINCIPLE in which maximum space is utilized was incorporated as the basis of the overall C-119 design. No tapered or circular design to lose valuable extra storage space.

REAR LOADING at truck bed height is easily accomplished by the rear center split compartment—the halves hinging outwards to allow direct loading of freight and equipment.



VERSATILE, the C-119 can be equipped either as a troop transport, litter carrier or heavy cargo aircraft. Paratroopers and equipment are easily dropped from the rear doors.



LONG- OR SHORT-DISTANCE HAULS covering a variety of military cargo ranging from "K" rations to six-ton trucks make the Packet the Air Force's most efficient transport plane.

ENGINE AND AIRPLANE CORPORATION

FAIRCHILD *Aircraft Division*

HAGERSTOWN, MARYLAND

Other Divisions: Fairchild-NEPA Division, Oak Ridge, Tenn. • Fairchild Engine Division, Guided Missiles Division, Al-Fin Division and Stratos Corporation, Farmingdale, N. Y.

I. A. S. News

A Record of People and Events of Interest to Institute Members

14th Wright Brothers Lecture: Aerodynamic Stability and Automatic Control

Dr. William Bollay, Director, Aerophysics Laboratory, North American Aviation, Inc., Selected as Wright Brothers Lecturer

THE FOURTEENTH WRIGHT BROTHERS LECTURE will be delivered on December 16 at the U.S. Chamber of Commerce Building Auditorium, Washington, D.C. This event marks the forty-seventh anniversary of the first flight of Orville and Wilbur Wright at Kitty Hawk. Members and guests are invited to attend.

Dr. William Bollay, Director, Aerophysics Laboratory, North American Aviation, Inc., has been chosen as this year's lecturer and will speak on "Aerodynamic Stability and Automatic Control." Dr. Bollay is planning to present a review of the evolution of dynamic stability analysis of aircraft illustrating the need for this analysis both for aircraft and missiles, followed by a summarization of the most useful theoretical and experimental techniques.

The Lecture Chairman will be Dr. Hugh L. Dryden, Director, N.A.C.A., and leading authorities in the field will act as discussers.

▸ **The Lecturer**—Born on January 14, 1911, in Stuttgart, Germany, Dr. Bollay attended the Evanston (Ill.) Township High School and was graduated in 1933 from Northwestern University's School of Engineering with a B.S. degree in Mechanical Engineering. He received his M.S. in 1934 and his Ph.D. in Aerodynamics (*summa cum laude*) 2 years later from California Institute of Technology.

During the scholastic year, 1933–1934, he was a Wind-Tunnel Assistant at CalTech, running various tests and calculating their results. While taking his residence work on his Ph.D., he was a Teaching Fellow and a Mathematical Assistant to CalTech's Dr. Th. von Kármán. Among other projects, Dr. Bollay assisted Dr. von Kármán in his scientific investigations of the theories of wave resistance, turbulence, and viscosity. He became an Instructor in Aeronautical Engineering at CalTech during the college year, 1936–1937, and taught courses in theoretical aerodynamics and hydrodynamics.

In 1937, he became associated with the Graduate School of Engineering at Harvard University as an Instructor in elementary aerodynamics and hydrodynamics, aerodynamics of the airplane, airplane structures, and airplane design. Dr. Bollay designed and constructed the Harvard Wind Tunnel. In 1940, he headed a supercharger research project carried out at Harvard by Pratt & Whitney Aircraft Division, United Aircraft Corporation. The following year, he and Dr. H. Emmons were placed in joint charge of Pratt & Whitney's supersonic wind-tunnel design and a supercharger research project at Harvard. During this same period, Dr. Bollay became a Consulting Engineer for United Aircraft's Hamilton Standard Propellers Division in a Theoretical Analysis of Propeller Flutter and Air Damping of Vibrations.

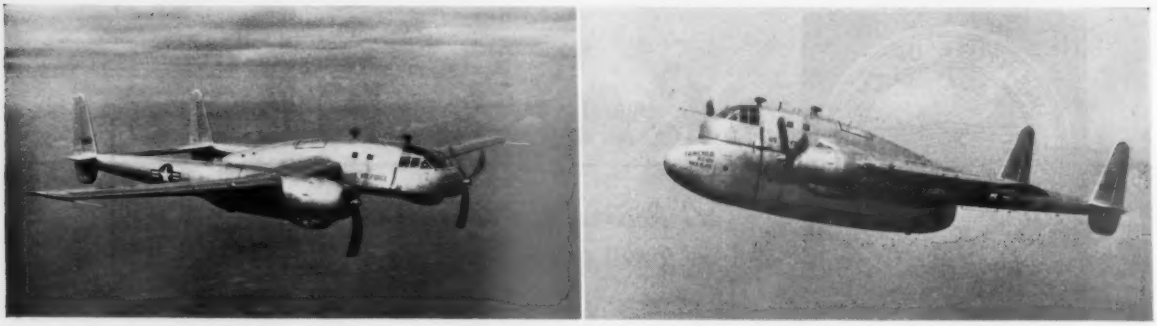
Dr. William Bollay, Wright Brothers Lecturer for 1950.

Dr. Bollay went on active duty with the U.S. Navy in 1941 in the Power Plant Design Branch, Bureau of Aeronautics. He was later awarded the Legion of Merit and a Permanent Citation "for exceptionally meritorious conduct in performance of outstanding service to the Government of the United States as officer in charge of Jet Propulsion and Gas Turbines developed in the Power Plant Design Branch, Bureau of Aeronautics, October 2, 1941–August 19, 1944."

Subsequent to his discharge from the Navy in 1945 with the rank of Commander, he became Director of North American's Aerophysics Laboratory. Since 1948, he has also been a Visiting Professor at the University of California at Los Angeles.

Dr. Bollay is a Fellow of the Institute and a member of the I.A.S. Council.

▸ **The Annual Lecture**—The Wright Brothers Lecture is an annual feature of the Institute of the Aeronautical Sciences. Endowed by The Vernon Lynch Fund, it was established in 1937. Every second year an aeronautical scientist from this country is selected as speaker, while on alternate years the lecturer is chosen from among aeronautical scientists abroad.



FAIRCHILD'S VERSION OF THE TRAILER TRUCK

The accompanying pictures show the XC-120 Pack Plane, designed by Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation, in flight both with and without its cargo-carrying fuselage, or "pod." A Pack Plane can fly into a field, have its fuselage detached almost instantly, and be ready to take off to pick up another fuselage within a matter of minutes. The "pod," which can be towed from beneath the plane on its own wheels, has both front and rear clamshell doors that open the entire cargo compartment for quick, direct loading. The XC-120 is powered by two 3,250-hp. Pratt & Whitney engines, has a 2,700-cu.ft. cargo capacity, and weighs about 64,000 lbs. fully loaded. It carries a crew of five.

Three Organizations Join I.A.S.; Guggenheim Center Established at Cornell

Recent additions to the ever growing list of corporations that are uniting with the Institute for the advancement of the aeronautical sciences are Cornell Aeronautical Laboratory, Inc., Cornell University, and Flight Safety Foundation.

Cornell Aeronautical Laboratory became a reality in 1946 when Curtiss-Wright Corporation presented the physical facilities of its Airplane Division Research Laboratory at Buffalo to Cornell University. Seven other large East Coast aircraft manufacturers generously contributed capital to assist in C.A.L.'s initial establishment. Originally operated by Cornell University through the Cornell Research Foundation, it was incorporated in March, 1948, and now functions as an autonomous unit with all capital stock held by the University. It operates in all fields of aeronautical research on a nonprofit basis. All funds from fees are used for fundamental exploratory research and for the support of education.

Cornell University, founded in 1868, received a considerable proportion of its original endowment from a Federal Land Grant, or Morrill Act of 1862, which specified that a leading object of the institution should be to teach "such branches of learning as are related to . . . . the mechanic arts." Today, Cornell University has established an exceptional aviation safety research organization under the direction of Dr. Theodore P. Wright, H.F.I.A.S., Vice-President for Research at Cornell University and President of Cornell Aeronautical Laboratory, Inc., with major projects at the home campus, at Cornell Aeronautical Laboratory, and at Cornell Medical College.

Flight Safety Foundation, under the direction of Jerome Lederer, F.I.A.S., since 1948, is financed by air lines, manufacturers, individuals, insurance organizations, oil companies, and by the sale of accident prevention bulletins. Its objectives are (1) to collect and disseminate accident prevention information pertaining to current operating problems, (2) to stimulate the adoption of proven safety practices and developments, and (3) to act as a sounding board for the exchange of honest differences of opinion with regard to controversial safety issues.

Last September it was announced that a new institution, to be known as the Daniel and Florence Guggenheim Aviation Safety Center, had been established at Cornell University. This Center is sponsored by the Daniel and Florence Guggenheim Foundation under the auspices of Cornell University. Jerome Lederer was appointed Director of the new Center. He will be concerned with the parallel operations of the Guggenheim Center and the Flight Safety Foundation. The New York headquarters of both are at the Institute's building at 2 E. 64th St.

The Guggenheim Center will not replace or overlap the work of any other aviation safety agency now in operation, but it will provide leadership, stimulate the cooperation of all agencies, and promote aviation safety research at qualified institutions throughout the country. Specifically, the main aims of the Center are (1) to stimulate research in the field of aviation safety by bringing together funds and facilities and (2) to encourage the integration of safety into aeronautical engineering curriculums at colleges so that graduates will be familiar with good practices from the safety standpoint.

It is expected that the association of Flight Safety Foundation with the Guggenheim Center will serve to strengthen both organizations. Flight Safety Foundation secures information that in turn will assist the educational and research activities of the Guggenheim Center and, conversely, the Guggenheim Center will help Flight Safety Foundation encourage safety research and stimulate safety thinking on the drawing board. These two are believed to be the only safety organizations devoted entirely to the problems of aviation.

The first project of the Guggenheim Center, a survey of aviation safety research activities, is now under way and is being conducted by Ruland M. Woodham, A.F.I.A.S., Aviation Engineering Executive and former Administrator of the Standard Aeronautical Indexing System at the Institute of the Aeronautical Sciences.

The general program and policies of the Guggenheim Center will be shaped by a Foundation Committee in which are represented the major Governmental and civilian agencies dealing

National Meetings Calendar

December 16	Wright Brothers Lecture, Washington, D.C.
Jan. 29–31, Feb. 1, 1951	Nineteenth Annual Meeting, New York
March, 1951	Flight Propulsion Meeting, Cleveland

with aviation safety. Members of the Committee are: Henry F. Guggenheim, H.M.I.A.S., President, The Daniel and Florence Guggenheim Foundation; Lt. Gen. F. Lawton Collins, Chief of Staff, U.S. Army; Vice Adm. John H. Cassady, Deputy Chief of Naval Operations (Air); Gen. Hoyt S. Vandenberg, H.M.I.A.S., Chief of Staff, U.S. Air Force; Vice Adm. Merlin O'Neill, Commandant, U.S. Coast Guard; Dr. Jerome C. Hunsaker, H.F.I.A.S., Chairman, N.A.C.A.; Delos W. Rentzel, H.M.I.A.S., Chairman, C.A.B.; Dr. G. Edward Pendray, Consultant, The Daniel and Florence Guggenheim Foundation; Dr. Wright; and Mr. Lederer.

Direct supervision of the Guggenheim Center's activities will rest with an Executive Committee under the chairmanship of Dr. Wright. Committee members include: Major Gen. James Gavin, U.S. Army; Comdr. William G. von Bracht, Head, Flight Safety Branch, Naval Operations, U.S. Navy; Major Gen. Victor E. Bertrandias, A.M.I.A.S., Director, Flight Safety Research, U.S. Air Force; Comdr. W. B. Scheibel, Executive Assistant, Search and Rescue Agency, U.S. Coast Guard; E. S. Hensley, Director, Office of Aviation Safety, C.A.A.; S. Paul Johnston, F.I.A.S., Director, Institute of the Aeronautical Sciences, Inc.; Dr. C. C. Furnas, F.I.A.S., Director, Cornell Aeronautical Laboratory, Inc.; Dr. W. G. Smillie, Professor, Public Health and Preventive Medicine, Cornell Medical College; Dr. Richard Parmenter, Coordinator of Research, Cornell University; A. W. Crowley, Associate Director of Research, N.A.C.A.; and Mr. Lederer.

New Harvard Professorship Honoring Charles E. Wilson

A new professorship honoring Charles E. Wilson, President, General Electric Company, has been established at the Graduate School of Business Administration-George F. Baker Foundation of Harvard University. The chair, to be known as the Charles Edward Wilson Professorship of Business Policy, was set up by the action of G-E's Board of Directors in recognition of Mr. Wilson's 50 years of continuous service to the company.

The Wilson Professor will devote himself to research and teaching the overall approach to business problems required by top management. He will direct the course in Administrative Policy, a requisite of all second-year students in the Harvard Business School.

B-36 MODERNIZATION

A portion of the B-36 modernization line at the San Diego plant of Consolidated Vultee Aircraft Corporation is shown. Here early models of the superbomber are being fitted with jet auxiliary power plants. The jet-augmented intercontinental bombers will have increased speed and will operate at altitudes above 45,000 ft. At the same time, Convair's Fort Worth Division is delivering new jet-equipped B-36D superbombers and RB-36 reconnaissance airplanes.

Dryden Presents Paper Before A.C.M.

Dr. Hugh L. Dryden, Director, N.A.C.A., presented a paper entitled "Application of High-Speed Computing in Aeronautical Research" at the September 9 meeting of the Association for Computing Machinery which was held at the Shoreham Hotel, Washington, D.C.

In describing the experience of the N.A.C.A. with high-speed computing machines in aeronautical research, Dr. Dryden cited various typical aeronautical problems requiring extensive research, such as Automatic Time Lag Problem and Aerodynamic Influence Coefficients. He gave the following advantages to be realized by the utilization of high-speed automatic computing equipment: speed, economy, the possibility of a more complete survey, and reliability. In concluding, Dr. Dryden predicted that "the outlook [for the future] is for a more intensive use of high-speed automatic computing machines." Significant factors that have figured in the increased demand are (1) the increasing number of nonlinear problems, (2) the increasingly complex theories needed to describe accurately the interrelated aerodynamic and structural behavior of aircraft at high speeds, and (3) the necessity for considering the effects of aerodynamic heating in high-speed missiles.

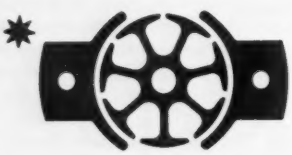
Flight Safety Elects Three to Board of Governors

Dr. Ross A. McFarland, M.I.A.S., was elected to serve on the Board of Governors, Flight Safety Foundation. Dr. McFarland, Associate Professor, Industrial Hygiene, Harvard School of Public Health, is a Research Fellow of Trinity College, Cambridge, and an honorary member of the American Medical Association. A member of the National Research Council Executive Committee on Selection and Training of Aircraft Pilots, Dr. McFarland was Medical Director, Pan American World Airways System, and in 1947 he received the Longacre Award in Aviation Medicine. During World War II, he served as Operations Analyst, Army Air Forces, in the Solomons. He is now a member of the Committee on Operating Problems, N.A.C.A.

In addition to Dr. McFarland, Adm. Edward H. Smith, U.S.C.G. (Ret.), Director of Woods Hole Oceanographic Institution, and Charles A. Rheinstrom, Vice-President, J. Walter Thompson Company, were also elected to the Board of Governors, Flight Safety.

A Dependable Source of Actuators

is essential.... especially now!



By manufacturing our own motors and other major components, we are able to offer the Aircraft Industry a source of supply on which it can rely for its greatly expanded requirements.

✱ *Laminations made with FORM GROUND dies produced by our own recently developed DUPLIform Grinder.*

AIRBORNE
ACCESSORIES CORPORATION
25 MONTGOMERY ST. • HILLSIDE 5, N. J.
LOS ANGELES, CAL. • DALLAS, TEX. • OTTAWA, CAN.

Aviation Country Club Dissolves

The unanimous decision of the members of the Aviation Country Club of Long Island, Inc., to dissolve the Club brings to an end its 22-year career. The 80-acre airport that was owned by the Club was sold last March, but a proposal to locate elsewhere had been under consideration. This possibility was voted down at a special meeting of the members on August 9. This dissolution and the conversion of old Roosevelt Field to an industrial area marks the conclusion of another chapter in Long Island's contribution to aviation history.

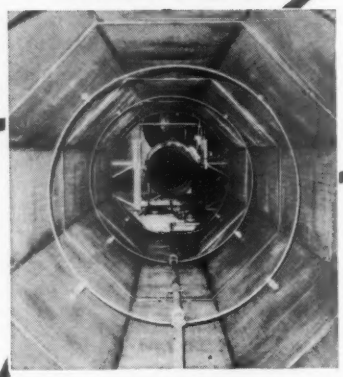
Included in the Club's roster were the following names: the late Charles Lanier Lawrence, Fellow and I.A.S. Past-President; George B. Post, M.I.A.S.; Grover Loening, I.A.S. Benefactor and Fellow; Brig. Gen F. Trubee Davison, M.I.A.S.; Earl D. Osborn, A.M.I.A.S.; Sherman M. Fairchild, I.A.S. Benefactor and Associate Fellow; Col. Charles A. Lindbergh, F.I.A.S.; A. Felix du Pont, Jr., A.M.I.A.S.; Harry F. Guggenheim, H.M.I.A.S.; Howard R. Hughes, M.I.A.S.; Lester D. Gardner, I.A.S. Benefactor and Fellow; Adm. John H. Towers, M.I.A.S.; Orie R. Kelly, A.M.I.A.S.; Rear Adm. Luis de Florez, F.I.A.S.; Franklin T. Kurt, A.F.I.A.S.; and Roger W. Kahn, M.I.A.S.

Gifts to the Institute Collections

The Cornell Aeronautical Laboratory, through the courtesy of James C. Evans, sent 138 slides of the air meet at Rheims in 1910, showing flight pictures of such pilots as Breguet, Bleriot, Farman, Latham, and Voisin, and several pictures of Glenn H. Curtiss at this meet. Colonel Edwin E. Aldrin added 400 magazines and several historical papers to his previous generous gifts. A photostat copy of *The Aerial Reporter*, Vol. 1, No. 6, Washington, D.C., August 14, 1852, published by the American aeronaut Rufus Porter, was received from Francis W. Hatch, of Boston, through the courtesy of Dr. Edward Warner. James M. Landis sent *A Headline History of the Air Pick-Up* (1942).

Hugh Harvey, of the Shell Oil Company, Inc., and R. Dixon Speas, of A. V. Roe Canada Ltd., contributed $25 for the purchase of books for the I.A.S. Library. Boris Sawa Kudravetz, of Philadelphia, sent 13 volumes of the *Transactions* of the American Society of Mechanical Engineers, for the years 1909 through 1923. Miss Pearl I. Young, of Pottsville, Pa., sent a typewritten bibliography of books and articles by and about John J. Montgom-

ISC
QUIETS
Jet and Reciprocating Engine Test Cells
Ends { ANNOYANCE / COMPLAINTS / THREATS of LEGAL ACTION
due to disturbing
NOISE



Interior of ISC Jet Aircraft Muffler

The roar of jet tests need no longer be an aircraft engine and air frame manufacturing problem!

Industrial Sound Control
JET AIRCRAFT MUFFLERS AND PANELS

cut the roar of jets to the level of surrounding neighborhood noises.

ELIMINATES EXCESSIVE WATER CONSUMPTION

Let us tell you how ISC engineering can quiet your operation—in the test cell—on the airstrip.

Write, wire or phone for further information.

INDUSTRIAL SOUND CONTROL
45 Granby St., Hartford, Conn.
2119 Sepulveda Blvd., Los Angeles, Calif.

ery, the California glider pioneer. A photograph of the University of Florida's BDG 1 glider, built in 1947 using the NACA 0012 symmetrical airfoil and having a wing loading of 6½ lbs. per sq.ft., was given by W. C. Lazarus.

The Physics Abstracting Study of the American Institute of Physics, through the courtesy of Dwight E. Gray, Director, sent its *Final Report* and a reprint of the article, "Abstracting and Indexing Services of Physics Interest." Herbert F. Miller sent a photograph of "Bill" Odom in flight at the National Air Races in 1949. The Standard Oil Company of California sent the papers of its "Turbine Engine Symposium," held in Los Angeles in July, 1950.

Technical data and photographs of airplanes were sent by the following Canadian companies: Canadair, Ltd.; Canadian Car & Foundry Company, Ltd.; Cancargo Aircraft Manufacturing Company, Ltd.; The de Havilland Aircraft of Canada, Ltd.; Found Bros. Aviation, Ltd.; and Northwest Industries, Ltd. Similar data were received from the following British companies: Airspeed, Ltd.; Sir W. G. Armstrong-Whitworth Aircraft, Ltd.; Boulton Paul Aircraft, Ltd.; Bristol Aeroplane Company, Ltd ; de Havilland Aircraft Company, Ltd.; English Electric Company, Ltd.; Gloster Aircraft Company, Ltd.; Handley Page, Ltd.; and Vickers-Armstrongs, Ltd.; from the following French companies: Société Anonyme des Ateliers d'Aviation Louis Breguet; Etablissements Fouga & Cie; and Société National de Constructions Aéronautiques du Nord; and from the following Spanish companies: Aeronautica Industrial, S.A.; and Construcciones Aeronáuticas, S.A. Similar data were also received from other countries as follows: Finland, Veljekset Karhumaki Oy.; Italy, Fiat, Direzione Uffici Tecnici Aviazione; Netherlands, N. V. Koninklijke Nederlandsche Vliegtuigenfabriek Fokker; Sweden, Svenska Aeroplan Aktiebolaget; and Turkey, T. H. K. Ucak Fabrikasi.

Technical reports were received from the British Joint Services Mission in Washington; Cornell Aeronautical Laboratory, Inc., courtesy of Miss Elma T. Evans; California Institute of Technology, courtesy of Dr. Clark B. Millikan; Douglas Aircraft Company, Inc.; University of Michigan, Aeronautical Research Center; Netherlands National Luchtvaartlaboratorium; North American Aviation, Inc.; Princeton University, Aeronautical Engineering Department, courtesy of Dr. Lester Lees; Shell Oil Company, Inc., courtesy of Hugh Harvey; Westinghouse Electric Corporation; and the U.S. Air Force School of Aviation Medicine, Air Materiel Command, Air University, Atomic Energy Commission, Bureau of Mines, Civil Aeronautics Board, Navy Bureau of Aeronautics, Navy Special Devices Center, Naval Ordnance Laboratory, Office of Naval Research, Congressional committees on appropriations, armed services, and interstate and foreign commerce, and the House and Senate Document Rooms.

Books and papers were also received from the Aeronca Aircraft Corporation, Allison Radar Sales Corporation, American Cyanamid Company, American Technion Society, *Aviation Week*, Beech Aircraft Corporation, Boeing Airplane Company, University of California, Curtiss-Wright Corporation, French Embassy, Georgia Institute of Technology, Harrison Radiator Division of General Motors Corporation, Indium Corporation of America, Iowa State College, Kinetics Chemicals, Inc., Lockheed Aircraft Corporation, Massachusetts Institute of Technology (Project Meteor), University of Missouri, University of Oklahoma, Port of New York Authority, Pratt & Whitney Aircraft Division of United Aircraft Corporation, Purdue University, Railway Express Agency, Rensselaer Polytechnic Institute, Rutgers University, Sikorsky Aircraft Division of United Aircraft Corporation, and L. J. Wing Company.

News of Members

▸ **Lawrence D. Bell** (A.M.), President and General Manager, Bell Aircraft Corporation, was awarded a Citation Plaque by the Air Force Association at its annual convention last August.

▸ **Dr. William Bollay** (F.), Technical Director, Aerophysics Laboratory, North American Aviation, Inc., also received a Citation Plaque from the Air Force Association at its annual convention.

▸ **L. P. Coombes** (A.F.), Director, Aeronautical Research Laboratory, Department of Supply and Development, Melbourne, Australia, was one of three Australian delegates at the 1950 conference of the British Commonwealth Aeronautical Research Advisory Committee, which was held last September in Canada. For a period prior to this conference, Mr. Coombes was in England where he examined research development there.

▸ **Dr. Donald H. Loughridge** (A.F.), Senior Advisor to Secretary, Department of the Army, Washington, D.C., was appointed to the Site Selection Committee, Research and Development Board. The purpose of the committee is the selection of the site for the proposed $11,000,000 Army Quartermaster Corps Laboratory.

▸ **Delos W. Rentzel** (H.M.), Chairman, C.A.B., was awarded the Airpower Trophy at the annual convention last August of the Air Force Association.

▸ **Frank N. Piasecki** (T.M.), Chairman, Board of Directors, Piasecki Helicopter Corporation, was elected to the Chairmanship, Helicopter Council, Aircraft Industries Association of America.

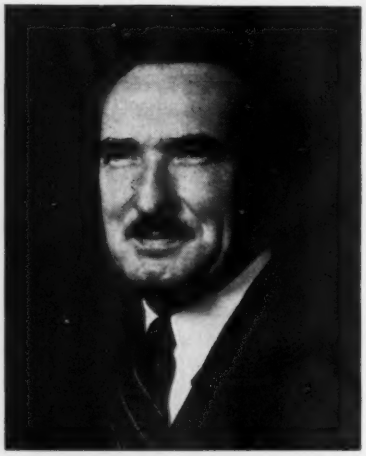
▸ **J. Parker Van Zandt** (F.), President, Aviation Research Institute, has become Special Consultant on Civil Aviation to the Assistant Secretary of the Air Force.

▸ **Dr. Theodore von Kármán** (H.F.), Chairman, U.S.A.F. Scientific Advisory Board, received the Science Award at the annual convention of the Air Force Association last August.

Attention Members!

All members of the Institute are invited to submit material concerning their activities for publication in the "News of Members" columns of the *Aeronautical Engineering Review*. Responsibility for new developments, awards or honors received, and appointments to new or additional positions are some of the items that your editors believe are of interest to other I.A.S. Members. A brief letter or postal card giving exact details will be sufficient. Photographs accompanying news items will be welcomed and will be used where practicable.

Items submitted will be considered on the basis of their timeliness and general interest. Correspondence should be addressed to the News Editor, *Aeronautical Engineering Review*, 2 East 64th Street, New York 21, N.Y.



NEW POSITION

Harold R. Harris (F.) became Vice-President in Charge of Atlantic Services, Pan American World Airways System, upon the consummation of the Pan American and American Overseas Airlines, Inc., merger. He was formerly Vice-President and General Manager, American Overseas. Mr. Harris, a Brigadier General in the A.T.C. in World War II, is a command pilot with 5,500 hours. He was Vice-President and Chief Operations Officer, Pan American-Grace Airways from 1929 to 1942, when he entered the Army's A.T.C. He joined American Overseas upon his discharge in 1945.

Members on the Move

This section has been instituted to give information on the latest affiliations of I.A.S. members. All members are urged to notify the News Editor of changes as soon as they occur.

Alexandre Berger (M.), now Vice-President in Charge of Research, Jacobs Aircraft Engine Company, a subsidiary of Republic Industries, Inc.

Comdr. Sheldon W. Brown, U.S.N. (A.F.) Director, Ships Installations Division, Bureau of Aeronautics, Department of the Navy, Washington, D.C. Formerly, Special Assistant for Research and Development, Under Secretary of the Navy, Washington, D.C.

Carl Chakmakian (T.M.), Research Engineer "B," Ford Motor Company. Formerly, Junior Engineer "B," Boeing Airplane Company.

Dr. Jagannath P. Chawla (M.), Hughes Aircraft Company. Formerly, Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn.

Carmine J. Colaluca, Jr. (T.M.), Secretary-Treasurer and Chief Engineer, Geco, Inc., New Canaan, Conn. Formerly, Fairchild Engine Division, Fairchild Engine and Airplane Corporation.

Murray Dryer (T.M.), Aeronautical Research Scientist, Lewis Flight Propulsion Laboratory, N.A.C.A. Formerly, Graduate Student, Department of Mechanical Engineering, Stanford University.

Harold W. Estill (T.M.), Junior Engineer, Project Design Group, Aviation Gas Turbine Division, Westinghouse Electric Corporation. Formerly, Graduate Student, Massachusetts Institute of Technology.

Laurence E. Fogarty (M.), Aerodynamicist, Aerophysics Laboratory, North American Aviation, Inc. Formerly, Ph.D. Candidate, Graduate School of Aeronautical Engineering, Cornell University.

Lt. Comdr. John L. Genta, U.S.N. (T.M.), Missile Test Division, N.A.-M.T.C., Pt. Mugu, Calif. Formerly, Flight Test, N.A.T.C., Patuxent River, Md.

Joel M. Jacobson (A.F.), Vice-President and General Manager, Aircraft Armaments, Inc. Formerly, Chief Structural Engineer, The Glenn L. Martin Company.

David H. Kaplan (T.M.), President, Convertawings, Inc. 347 Madison Ave., New York, N.Y. Formerly, Project Engineer, Doman Helicopters, Inc.

W. H. Kearns-Batchelor (A.M.), now Inspector, British European Airways Corporation.

Warren G. Kingsley (T.M.), Carburetor Engineer, Eclipse Machine Division, Bendix Aviation Corporation. Formerly, Inspector, Delco Appliance Division, General Motors Corporation.

K. H. Larsson (M.), Canadair, Ltd. Formerly, AB Aerotransport, Scandinavian Airlines System.

John W. Ludwig (M.), Supervisor, Flight Test Instrumentation and Electronics Laboratory, Chance Vought Aircraft Division, United Aircraft Corporation. Formerly, Head, Applications Engineering Department, Askania Regulator Company.

Walter F. McGinty (A.F.), Chief Engineer, Lockheed Aircraft Corporation. Formerly, Sales Representative, Lockheed Aircraft Service, Inc.

David L. Mellen (T.M.), Aeronautical Research Engineer, Minneapolis-Honeywell Regulator Company. Formerly, Senior Analytical Engineer, Chance Vought Aircraft Division, United Aircraft Corporation.

2nd Lt. Bernard P. Miller, U.S.A.F. (T.M.), now with Headquarters, Air Materiel Command, Box 485, Wright-Patterson Air Force Base, Ohio.

Stanley Nesbitt (T.M.), now Project Engineer, Plastic Manufacturers, Inc., Stamford, Conn.

B. G. Reed (M.), Assistant Division Manager, Fort Worth Division, Consolidated Vultee Aircraft Corporation. Formerly, Vice-President, Northrop Aircraft, Inc.

William H. Renison, Jr. (A.F.), General Superintendent, Maintenance Directorate, McClellan Air Force Base, Calif. Formerly, Industrial Management Engineer, Overhaul and Repair Department, Naval Air Station, Alameda, Calif.

VISITING PROFESSOR

Joseph Kampé de Fériet (F.), Professor, Faculty of Sciences, The University of Lille, Lille, France, is currently Visiting Research Professor at the Institute for Fluid Dynamics and Applied Mathematics, University of Maryland, until the end of January, 1951. Professor Kampé de Fériet is giving a series of lectures on the Spectral Analysis of Turbulence, as well as several conferences on Stochastic Processes. The Institute for Fluid Dynamics and Applied Science is a research organization sponsored by the University of Maryland and the Naval Ordnance Laboratory. Dr. Raymond J. Seeger (A.F.) is Acting Director.

Donald F. Samhammer (T.M.), Engineering Draftsman, Chicago Pneumatic Tool Company, Utica, N.Y. Formerly, with the same company in Detroit.

Dr. M. C. Shelesnyak (M.), Department of Experimental Biology, Weizmann Institute of Science, Rehovoth, Israel. Formerly, Director, Baltimore-Washington Office, Arctic Institute of North America.

Lt. Comdr. Howard Lee Smolin, U.S.N. (M.), Airship Development Squadron 11, Naval Air Station, Key West, Fla. Formerly, Engineering Officer, Experimental Center, Naval Air Station, Lakehurst, N.J.

Edward N. Stevensen, Jr. (M.), Kaman Aircraft Corporation. Formerly, Aeronautical Engineering Department, West Virginia University.

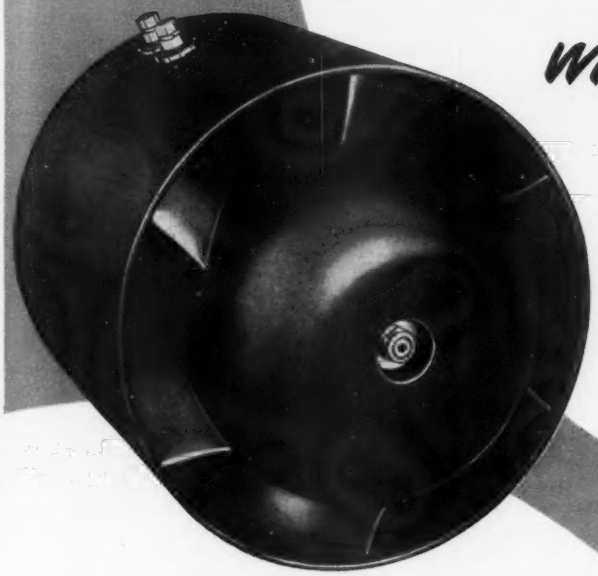
John R. Strandell (T.M.), Engineer in Charge of Tool Design and Welding, Bentley Weldery, Inc. Formerly, Jr. Engineer "B," Boeing Airplane Company.

Patricia A. Strandell (T.M.), now Draftsman, Electronics Division, General Electric Company.

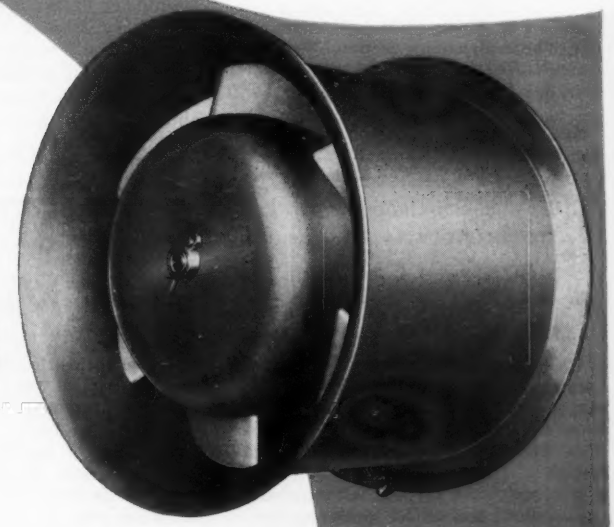
William E. Thompson (T.M.), Department of Mechanical Engineering, Illinois Institute of Technology. Formerly, Junior Mechanical Engineer, Cornell Aeronautical Laboratory, Inc.

SAVE WEIGHT, SPACE and POWER

with JOY AXIVANE* FANS



Specially Designed for AIRCRAFT VENTILATING SYSTEMS



JOY AXIVANE FANS answer perfectly the aircraft industry's need for a light, compact fan in a wide selection of sizes, ranging up to types with the capacity needed to service the largest airplanes. High efficiency results from the JOY vaneaxial construction, which permits high volumes and pressures with minimum power consumption.

JOY Fans for aircraft ventilating systems are available in 18 standard models, ranging in air output from 60 to 4400 CFM at 1" to 6.5" water-gauge pressure. Weights range from 5 to 51 lbs.; sizes from 3½" to 14" in diameter; and power input from .04 to 7.5 hp. Special sizes to meet *your* individual needs are available to order . . . *write for bulletin.*

Consult a Joy Engineer

* *Registered U. S. Patent Office*

W&D A2274

JOY MANUFACTURING COMPANY

GENERAL OFFICES: HENRY W. OLIVER BUILDING · PITTSBURGH 22, PA.

IN CANADA: JOY MANUFACTURING COMPANY (CANADA) LIMITED, GALT, ONTARIO

Hugh T. Weaver (T.M.), Engineering Draftsman, Electronic Controls Group, Lear, Incorporated. Formerly, Student, Cal-Aero Technical Institute.

Charles R. Weiss (T.M.), Designer, Engineering Department, Timkin Roller Bearing Company. Formerly, Draftsman, Maintenance Depot, American Airlines System.

William A. Wildhack (M.), Head, Office of Basic Instrumentation, National Bureau of Standards. Formerly, Chief, Missile Instrumentation Section, Electronics and Ordnance Division, National Bureau of Standards.

Clifford E. Willis (M.), Assistant Sales Manager in charge of Lear West Coast Sales and Field Engineering, Electro-Mechanical Division, Lear, Incorporated, Los Angeles. Formerly, Manager, New York Office, Lear.

Dana Young (M.), Mechanical Engineering Department, University of Minnesota. Formerly, Department of Engineering Mechanics, University of Texas.

Robert W. Young (T.M.), Aerodynamicist, Thermodynamics Section, Northrop Aircraft, Inc. Formerly, Marine Engineer, San Francisco Naval Shipyards.

Samuel J. Zeigler (M.), Eastern Engineering Representative, Solar Aircraft Company, Washington, D.C. Formerly, with Solar, Des Moines.

Necrology

Omer Lee Woodson

Omer Lee Woodson, A.F.I.A.S., Vice-President in Charge of Production, Radioplane Company, Van Nuys, Calif., died of a heart attack at his home, 11708 Sunshine Terrace, Studio City, Calif. Funeral services were held at the Church of the Recessional, Forest Lawn, on Thursday, March 2.

Born in Dalton, Ky., on April 26, 1895, Mr. Woodson began his career 19 years later as a mechanic. During World War I, he served in the Air Service Branch of the U.S. Army Signal Corps. He took his flight training in France in 1917 and became a military aviator with 1,600 hours logged. For 3 years following his discharge, he was associated with Service Aviation and Transport Company, and in 1921 he entered the U.S. Airmail Service. From 1925 to 1930, he was with Woodson Engineering Company, Woodson Aircraft, and Simplex Aircraft. In the thirties, he joined successively Northrop Air raft, Inc., and Curtiss-Wright Corporation. He became Vice-President and Assistant General Manager of Bell Aircraft Corporation in 1939 and 4 years later became Vice-President and Manager of Bell's Georgia Division. In 1945, he formed the O. L. Woodson Company, an industrial consulting engineering firm. About 2 years ago, he became associated with Radioplane Company as Director of Research and the following year was made a Vice-President.

▶ **Flight Instruction Patent**—Mr. Woodson patented an idea to teach flying without employing dual instruction. This plan is said to have been in successful operation since 1941 and to have taught many students to fly. He designed and constructed in 1919 the first six-passenger closed-cabin plane in America. Mr. Woodson contributed papers to various technical journals and was also a member of the S.A.E., N.A.A., Q.B., and V.F.W.

He is survived by his wife, Clara and three daughters.

Corporate Member News

• Cover-Stripping Tool . . . **Aeroquip Corporation** has available a Hose-Cover Stripping Tool for removing the outer cover from Aeroquip Double and Single Wire Braid Hose before attaching the fittings.

• Test Set . . . A portable self-contained mixer crystal test set for measuring conversion loss and noise temperature of silicon crystals has been designed and is being produced by **Airborne Instruments Laboratory, Inc.** This instrument, A.I.L. Type 390, is intended for use at or below 10,000 mc. for direct indication and above 10,000 mc. for relative indication . . . A current backlog of nearly $6,000,000 in research and development projects was reported at the annual meeting of the Board of Directors. All directors of A.I.L. were re-elected.

• New Turbosupercharger . . . The **Aircraft Gas Turbine Division,** General Electric Company, has developed a new turbosupercharger, designated the CH9, which eliminates the impeller and has no mechanical connection between the engine and turbo. The CH9 turbo handles up to 350 lbs. of air per min., compressing it to a pressure of 50 in. of mercury, absolute. Tests of the P. & W. R.-4360-C engine with the CH9 turbo show 32 per cent more take-off power and 20 per cent lower fuel consumption than is realized from the same power plant using a current production turbosupercharger, the BH-4.

• Separate Division . . . The Allison-Bedford Foundry, formerly operated by **Allison Division, General Motors Corporation,** has been made a separate division of the corporation and is to be known as the Bedford Foundry Division.

• Folder . . . A means of combining algebraically two mechanical quantities measured by angular displacement is described in a folder titled *Arma Mechanical Differentials*, released by Arma Corporation, Brooklyn, a subsidiary of **American Bosch Corporation.**

• Wheel Spinner . . . A small hydraulic-powered device, said to be capable of spinning the heaviest aircraft wheels to the equivalent of 150 m.p.h. ground speed in drop testing landing gear is being used in the laboratories of **Bendix Products Division, Bendix Aviation Corporation.**

• Expansion . . . Investment of approximately $3,000,000 of **Boeing Airplane Company** funds to increase the company's Seattle research and manufacturing facilities was approved by the Board of Directors. Half of the amount will be used for the expansion of Boeing's wind tunnel, known officially as the Edmund T. Allen Memorial Aeronautical Laboratories. The remainder will cover new machines and tools as well as additional office accommodations . . . The first of the new-type Boeing KB-29P Flying Boom aerial tanker airplanes was delivered September 9 to the 97th Aerial Refueling Squadron, the first such squadron to receive this new equipment. The modified B-29 Superfortress allows bombers and other U.S.A.F. aircraft to refuel in flight.

• Motors for Research . . . Fractional horsepower, two-phase, reversible 60-cycle motors, produced by **Brown Instrument Division, Minneapolis-Honeywell Regulator Company,** are available for applications requiring a low-inertia drive motor with power requirements low enough to permit field excitation from an electronic amplifier.

• Endurance Record . . . The XP5Y-1 Navy patrol seaplane, built by **Consolidated Vultee Aircraft Corporation,** established a new American and world flight endurance record for turboprop aircraft during August, it was announced by LaMotte T. Cohu, Convair's President and General Manager. The 60-ton flying boat, powered by four XT40 Allison gas-turbine engines of 5,500 hp. each, was in the air 8 hours and 6 min. . . . A new engine test stand, consisting of a B-36

From tree-top to 50,000 feet (and more)

How to maintain CONSTANT CABLE TENSION in Your aircraft is important!

- *Under all conditions and altitudes of flight*
- *Under temperatures ranging from —65° to 160°F.*

STURGESS CABLE TENSION REGULATORS are designed to maintain constant control cable tension under all flight conditions in all types of aircraft. In large transports, bombers, and fast fighter craft where instant maneuverability means life or death. STURGESS "BUILT-IN REGULATORS" are entirely mechanical in operation and light in weight. Durable construction gives them an efficient wearing life equal to any other structural part.

STURGESS BUILT-IN REGULATORS improve the stability and flight characteristics by preventing slack cables in extreme cold and over-taut rig under high temperatures. They prevent erratic control due to structural distortion from heavy cargo or pressure cabins and permit the use of lower rigging tension because it remains dependably constant, which increases the ease of handling in any plane under all fiight conditions.

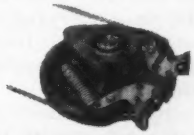
STURGESS CABLE TENSION REGULATORS are manufactured in two general types. 1. Standard units for installation in existing systems. 2. Built-in units, designed as an integral part of a quadrant, sector or drum.

Type R 72

Typical standard type unit. Incorporates two telescopic tubes for rig load springs, mounted one on each side of main frame brake assembly. Various sizes are available depending on rig requirements. Ideal for confined area installation.

MODEL R 80 QUADRANT

Built-in type used in one of our most famous bombers. This type is ideal for large transports or bombers where great structural flex takes place. This regulator provides constant cable tension as an integral part of a quadrant structure.



MODEL R 81 QUADRANT

Built-in Type. Using actuated arm and sliding cable operation this type unit is ideally adapted to control systems having high design loads. Designed to operate in small, confined area installation such as in fighter aircraft.

All Sturgess Regulators are designed and manufactured to your specifications. We can help you with your control system problems . . . . . Write now!

To speed up engine change by automatically rigging the system . . . use

***AUTO-RIG DISCONNECT**

*Trade mark

ABSOLUTELY SAFE, cannot be over-rigged! Ideal for secondary control cable installation. Locked in operation, AUTO-RIG can be released in a matter of seconds. AUTO-RIG can be furnished in two types of fittings . . . Plain ball or Ball-shank terminal.

Pacific SCIENTIFIC CO.

1430 Grande Vista Ave., Los Angeles 23, Calif.
25 Stillman St., San Francisco 7, Calif.
1915 1st Ave. South, Seattle 4, Wash.

EASTERN REPRESENTATIVE
Aero Engineering, Inc.
Roosevelt Field, Mineola, N.Y.

LEDEX

RELAYS and CIRCUIT SELECTORS

ROTARY SOLENOID OPERATED

- REMOTE CONTROL
- SELF-STEPPING OR EXTERNAL IMPULSING
- POSITIVE DETENT ACTION

for REMOTE CONTROL of MULTIPLE COMPLEX CIRCUITS

Many versatile designs of stepping, counting, adding and subtracting, latching, and *circuit selecting* relays are made possible by the combination of the Ledex Rotary Solenoid and wafer type rotary switches. Self-stepped or externally impulsed, the device is immediately adaptable to many remote control applications. A choice of wire sizes permits a wide range of operating voltages and power requirements. Various types of mountings further increase its adaptability. In addition to its positive control of multiple, complex circuits, a reserve of mechanical power is available for the performance of duties other than switching operations.

We supply to quantity users and solicit the opportunity to be of assistance in solving multiple circuit relay problems.

WRITE DIRECT TO

G.H. Leland INC.

101 WEBSTER STREET

DAYTON 2, OHIO

inboard nacelle and wing section, is in operation at Convair's Fort Worth Division. This new test stand permits engineers to simulate engine operations under varying conditions: idling, cruising, full military take-off power, and any intermediate speeds . . . Convair-Liner commercial transports have been approved by the C.A.A. to take off at a gross weight of 41,790 lbs., an increase of 1,290 lbs. More than 160 of these transports now in service throughout the world can be licensed at 41,790 lbs. after modification.

• Eight-Bladed Prop . . . A dual-rotation propeller of hollow steel construction, developed by **Propeller Division, Curtiss-Wright Corporation,** has been delivered to the A.M.C. for extensive tests. Nicknamed the "Octoprop," it is designed for use with a gas-turbine engine of 10,000 to 15,000 hp.

• New Offices . . . **Douglas Aircraft Co., Inc.,** has moved its New York office to new quarters at 230 Park Ave., New York 17, N.Y.

• Booklet . . . **Dynamatic Corporation,** a subsidiary of Eaton Manufacturing Company, has published a booklet entitled *Water-Cooled Couplings for Adjustable-Speed Drives from A.C.*

• New Order . . . **Eastern Air Lines, Inc.,** has placed an order with Lockheed Aircraft Corporation for four additional Super Constellations. This is in addition to the ten 92-passenger air liners ordered by Eastern last April.

• Supplement . . . **Eaton Manufacturing Company** recently forwarded to the Institute of the Aeronautical Sciences sufficient copies of its *1949 Supplement to A Chronicle of the Aviation Industry in America,* to permit the supplying of the entire I.A.S. membership.

• New Plants . . . The construction of new manufacturing plants near Houston, Tex., for the increase of the **Ethyl Corporation's** production of antiknock compounds is scheduled to be completed by the end of 1951.

• Converted . . . A C-82 Flying Boxcar, built by **Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation,** has been converted into a medium assault transport plane. The C-82 is one of three different assault transport planes to undergo evaluation tests at Eglin Air Force Base, Fla.

• Spectrometer . . . A mass spectrometer, developed by General Engineering & Consulting Laboratory, **General Electric Company,** was recently installed at the research center of The B. F. Goodrich Company . . . The General Electric Research Laboratory will celebrate its fiftieth anniversary the week of October 9 with the dedication of its new home in Niskayuna Township, N.Y.

• Catalog . . . **The B. F. Goodrich Company** has put out a catalog on *Adhesives* that lists by number each adhesive it manufactures, the materials for which they are specifically recommended, and the method by which the most effective bond is created.

• Airship . . . The ZPN airship, the construction of which is well under way at **Goodyear Aircraft Corporation, The Goodyear Tire & Rubber Company,** is identified as the "N" type. The N-ship's envelope will have a capacity of 875,000 cu.ft. of helium gas. The power plant will be two seven-cylinder single-row engines, each driving two 18-ft., three-bladed, Curtiss electric, full-feathering controllable-pitch reversible propellers. Speed in the neighborhood of 75 knots is anticipated. Total time for design and construction will approximate 2 years.

• Warpage Elimination . . . The Metallurgical Department, **Harvey Machine Company, Inc.,** has announced that the difficult problem of warpage while machining large aluminum-alloy heat-treated sections has been registered as "solved."

• Mach Number Chart . . . **Kollsman Instrument Division, Square D Company,** is offering gratis to the engineering departments of organizations in aviation and allied fields its *Kollsman Mach Number Chart.* The chart gives the standard values for measurement of high speeds in terms of Mach Number, indicated air speed, differential pressure, altitude, and absolute pressure. Pressure ratios, differential pressures, and stagnation pressures for various Mach Numbers are provided in tabular form.

• Autopilot . . **Lear, Incorporated,** gave the first demonstration last August of the Autopilot, designated the L-2. This automatic pilot, weighing 36.15 lbs. complete, is small enough to be installed in personal and executive-type aircraft . . . Lear has completed delivery to the U.S.C.G. on an order of approximately $70,000 for its Marine Automatic Direction Finders.

• Australian Representative . . . **Lockheed Aircraft Corporation** has appointed E. L. Haymanson Company as its sales representative in Australia.

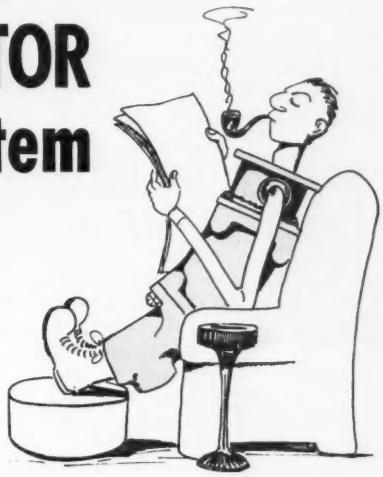
• Bombing . . . Heavy bombs, weighing from 500 to 4,000 lbs., have been safely and accurately dropped at speeds over 500 m.p.h. and at varying altitudes up to more than 20,000 ft. in tests with the jet-propelled B-45 Tornado bomber, built by **North American Aviation, Inc.**

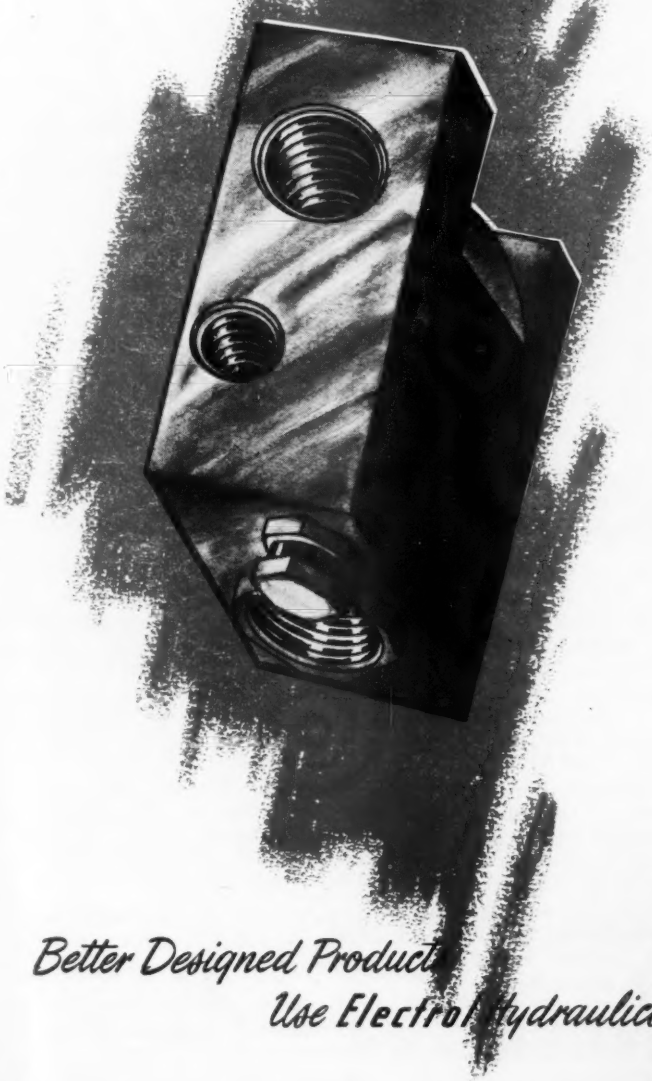
• Merger Completed . . . **Pan American World Airways, Inc.,** formally took over American Overseas Airlines, Inc., on September 25 for $17,450,000 and began service on those transatlantic routes formerly operated by A.O.A. Among other assets of A.O.A., Pan American acquired eight Stratocruisers and seven Constellations . . . Pan American has replaced the DC-4 with Constellation-type Clippers on five of the seven weekly flights to South America. The Constellations' flights end at Caracas, Venezuela, while the DC-4 Sleeperettes terminate at Buenos Aires, Argentina . . . Pan American is losing 59-year-old Capt. Fred V. Clark, who is retiring after more than 21 years with the company. Captain Clark joined P.A.A. in 1929 after approximately 21 years in the U.S. Navy. In his 33 years of flying, he has logged over 21,400 hours . . . Pan American's Latin American Division has temporarily "loaned" Kenneth E. Calender, Airport Engineer, to the Puerto Rican government. He will act as consultant

(*Continued on page 84*)

Hydraulic Pumps Take It Easy

When the Electrol PRESSURE REGULATOR Is Part of the System





Electrol's military approved, light-in-weight Pressure Regulator—or Unloading Valve—is designed to relieve power driven pumps from working pressure loads, whenever the hydraulic system is between cut-out and cut-in range. The valve provides free flow of the hydraulic fluid at low pressure through the pump delivery line back to the reservoir, without relieving pressure from the working parts of the system. It cuts in at 2,700 p.s.i. and cuts out at 3,000 p.s.i. Write for further details.

Better Designed Products Use Electrol Hydraulics

Electrol
INCORPORATED
KINGSTON, NEW YORK
CYLINDERS · SELECTOR VALVES · FOLLOW-UP VALVES
CHECK VALVES · RELIEF VALVES · HAND PUMPS
POWERPAKS · LANDING GEAR OLEOS · SOLENOID
VALVES · ON-OFF VALVES · SERVO CYLINDERS · TRANSFER
VALVES · CUT-OUT VALVES · SPEED CONTROL VALVES
FOR BETTER HYDRAULIC DEVICES

Meet Your Section Chairmen

Ezra Kotcher

Dayton Section

Ezra Kotcher, who for the past 4 years has been Director, U.S.A.F. Institute of Technology, Wright-Patterson Air Force Base, attended the Universities of California and Michigan and was graduated with B.S. and M.S.A.E. degrees. It was back in 1926, while a sophomore in college, that Mr. Kotcher first decided on aeronautics as a profession, for he "saw opportunities to pioneer and grow with a new and fascinating engineering field."

Mr. Kotcher was with the Air Corps Engineering School at Wright Field from 1928 to 1941, completing this tour as Senior Professor of Aeronautics. From the time of Pearl Harbor until entering military service in July, 1942, he was Senior Aeronautical Engineer, Bombardment Branch, Engineering Division, A.M.C. In his present position, he supervises the technical education of Air Force officers in engineering sciences and industrial administration.

A Lieutenant Colonel, U.S.A.F. Reserve, Mr. Kotcher has been Project Officer for Flight Refueling of the B-17 by the B-24 and for Jet Fighters and the XS-1 (now the X-1), as well as Chief, Guided Missile Branch, Engineering Division, A.M.C. He is a member of the N.A.C.A. Subcommittee on Jet and Turbine Power Plants and the N.A.C.A. Special Committee on Self-Propelled Guided Missiles.

Some of the papers authored by Mr. Kotcher include "Compressibility Factors in Converting Indicated to True Airspeed," "Pressure-Time Relations in Punctured Fuselage," and training manuals on *Engine Design, Fluid Dynamics for Aircraft Designers*, etc. He developed an Exact Airspeed Computer that works on the principle of establishing true air speeds via the determination of Mach Numbers.

When asked about the most interesting episode of his career, he replied: "After feverishly working all night to assemble our first reproduction of the German buzz bomb for a scheduled demonstration launching on 12 October 1944 for the Brass Hats and V.I.P.'s without benefit of a single preliminary test, I gave the order, 'Fire!' and several hundred pounds of rocket propellant went off in a loud hiss and the V-1 took off in a cloud of smoke and the darn thing actually flew for a couple of miles before it splashed into the Gulf of Mexico."

Mr. Kotcher was the first military passenger in jet aircraft in the United States, or possibly, in the world. However, he qualifies this by saying that "the low value of the claim will be readily appreciated when I tell you that about 20 civilians of Bell Aircraft Corporation flew before I did!"

Mr. Kotcher and his wife, the former Etta Jean Horwitz, are the parents of two daughters: Nina, aged 17, and Linda, aged 12. In addition to being "handy-man-about-the-house," his hobbies consist of oil painting and woodworking.

R. Dixon Speas

New York Section

Robert Dixon Speas, United States Representative, A. V. Roe Canada Limited, is another whose decision to enter the field of aeronautics as a profession was predicated upon Col. Charles A. Lindbergh's history-making transatlantic flight in 1927. Mr. Speas' first employment as an aeronautical careerist was in the dual capacity of Aviation Reporter for the Winston-Salem (N.C.) *Journal-Sentinel* and Aviation Commentator for the local radio station WSJS. This was in 1935.

Born in Davie County, N.C., he was a pupil in the "Tarheel" public school system. In 1937, he won the first award in the annual Boeing Thesis Competition, which permitted him to attend the Boeing School of Aeronautics. While at Boeing, he obtained his Commercial Pilot's Certificate and worked in the Sales Department of Trans World Airlines.

After his graduation in 1940 from the Massachusetts Institute of Technology with a B.S. degree, he entered the employ of American Airlines System. Starting in the Engineering Department, he was later placed in charge of engineering and maintenance of the Contract Air Cargo Division. At the time of his resignation from A.A. this year, he was Special Assistant to the President.

Mr. Speas received the 1942 award of the Air Transport Association of America for the "best air-lines dispatching and meteorology research of the year." Two years later, he was cited by a national magazine as one of the ten outstanding young men in the aviation industry. He has authored *Airplane Performance and Operations*, *Pilot's Technical Manual*, and *Airline Operations*. He has also written various articles and papers on technical and general phases of air transportation and aviation during the past several years.

Mr. Speas is a member of the Institute's Meeting Committee and Air Transport Editorial Committee.

He and his wife, the former Nanette Hollingsworth, a Purdue Engineer, are the parents of a boy, aged $3\frac{1}{2}$, and a girl, aged $1\frac{1}{2}$.

CMH REX-FLEX Stainless Steel Flexible Metal Hose and Ducting

Whether it's a cross ignition tube for the newest jet job or ducting for the pilot's foot warmer in an air freighter, there's a CMH flexible metal hose product to do the job more dependably and with greater safety. At CMH, years of experience is combined with the most modern fabrication methods to produce stainless steel ducts . . . hose . . . connectors . . . and bellows that assure high flexibility and maximum resistance to fire, fatigue and high and low temperatures.

CMH REX-FLEX flexible metal hose products are made in sizes and types to meet virtually all aircraft requirements. For complete information on specific assemblies to meet your needs, send details of your application.

In the illustration above CMH REX-FLEX flexible metal hose is used as generator blast tube in a current transport model. Note the flexibility which simplifies installation without sacrificing any of the necessary qualities of resistance to heat and vibration.

Flexon identifies CMH products that have served industry for over 48 years.

CHICAGO METAL HOSE Corporation

1309 S. Third Avenue • Maywood, Illinois • Plants at Maywood, Elgin and Rock Falls, Ill.
In Canada: Canadian Metal Hose Co., Ltd., Brampton, Ont.

CMH

ONE DEPENDABLE SOURCE
for every flexible metal hose requirement

Convoluted and Corrugated Flexible Metal Hose in a Variety of Metals • Expansion Joints for Piping Systems
Stainless Steel and Brass Bellows • Flexible Metal Conduit and Armor • Assemblies of These Components

Editorial

Man with a Mission

The Age of Respectability for "Rocketeering" is amazingly short. You can almost calculate it on the fingers of one hand. Only yesterday, to express any serious interest in the possibility of direct reaction propulsion for anything but Fourth-of-July purposes was to invite examination by the family psychiatrist. But the shattering roar of V-2's exploding in London's streets in the winter of 1944–1945 changed the picture. Phantasmagoria became brutal reality. The lid was off.

Almost 30 years before that time, however, there was one man who through a long and active life of study and research never doubted that such things would come to pass. During the 20-odd years between World War I and World War II so many raised eyebrows had been aimed in his direction that he might well have concluded that that was the normal configuration of the human face.

Such things, however, bothered him not at all. He was too busy in his workshops and laboratories to pay any attention. Early in his career, he was convinced that rocket power was theoretically feasible. The remainder of his life was dedicated to finding how to bring it into the realm of practicality. Few men have worked at anything with such single-mindedness and concentration. It was uphill all the way. Recognition came late—almost too late. Only after his death has the full stature of Robert H. Goddard, Father of Rocketeering, been recognized.

This is not the place to recount the story of Dr. Goddard. Several books on the subject are now available, and a brief account will be found in AERONAUTICA, the Institute's Historical Bulletin (Vol. 2, No. 4, October–December, 1950). We salute here, however, the memory of a great man, a scientist and an engineer, whose work was fully 20 years ahead of his time and from whose genius stemmed today's solution of many problems in propulsion for supersonic missiles and aircraft.

We of the Institute have more than a technical interest in Dr. Goddard's work. Recently, his widow, Mrs. Esther Goddard, presented to our Archives not only her husband's entire library on rocket propulsion (including his own records of his experiments) but also hundreds of the actual rocket parts and mechanisms that were tested in the course of his work. The collection includes a prototype of a "bazooka" which was developed and ready for production by the end of World War I in 1918, as well as many examples of successful and unsuccessful liquid-fuel rocket motors, controls, tanks, instrumentation, firing mechanisms, fuel pumps, turbines, and whatnot from the period of experimentation at Worcester, at Roswell, N.M., and at Annapolis in World War II. All these things have been assembled in the Goddard Memorial Room at 2 East 64th Street where they form a most interesting and valuable addition to the Institute's collection of aeronautica.

Every member of the Institute may be justly proud that we were selected to be the custodian of these irreplaceable records of the life work of a man who, in spite of constant ridicule and opposition, was not afraid to think so far ahead of his time. We need more people of that caliber. The presence of the Goddard collection will serve as a constant reminder.

To you, Mrs. Goddard, our sincerest thanks.

S. P. J.

Dr. Robert H. Goddard.

The Application of Pressure Refueling to Flight

GEORGE E. WOODS-HUMPHERY*

Flight Refueling, Inc.

Introduction

IT IS A SINGULAR COMMENTARY on the art in which we are engaged that the modern airplane is still the same machine, fundamentally, as that conceived and demonstrated by the Wright brothers 47 years ago. Nearly 5 decades of intensive research, experiment, and development in all parts of the world, with forced growth nurtured by two world wars, have failed to produce any radical change in that original concept of flight in heavier-than-air craft.

Stated simply, that concept was to provide a machine with enough energy to become air-borne and to remain air-borne until it could land and acquire more energy.

True, we can fly faster and farther with greater certainty. We can carry far heavier loads. Yet all these tremendous improvements have been accomplished by refining the materials we use—the power plants, the air frame, and the instrumentation.

We still *think* of flying in terms of the same compromise the Wright brothers accepted nearly half a century ago.

The true element of the airplane is the air. To achieve flight, however, the Wright brothers had to design a machine capable not only of sustained, controlled flight; they also had to modify that machine until it was first capable of lifting itself off the ground. That expedient demanded of the airplane its maximum effort at the very time when it was burdened with its maximum load—that is to say, under the most adverse conditions in its working cycle.

We know that an airplane, like a man or an animal, can *carry* more weight than it can lift off the ground. In aircraft, the amount of this added load capability varies with the design. However, if we admit only 10 per cent as an average, our acceptance of the classic "Kitty Hawk Compromise" imposes an initial penalty of 10 per cent on the air-borne efficiency of the airplane.

It is remarkable how our acceptance of this penalty has remained unchanged. It is even more remarkable when we begin to study where that acceptance has led us. To gain greater speed, greater range, and greater load, we have been forced to build bigger and bigger airplanes. Bigger airplanes required more power, and more power demanded more fuel; so we have had to build already big airplanes still bigger to accommodate larger and larger fuel loads.

By accepting size as the major solvent for our demanded elements of speed, range, and load, we have actually compounded both the limiting effects of that compromise and the terrific cost it demands. We know that, headed in that direction, we have been traveling down a dead-end road of diminishing returns. Today, the emergence of jets and the promise of rocket power,

Presented at the Session on Propulsive Systems, Annual Summer Meeting, I.A.S., Los Angeles, July 12–14, 1950.

* President.

by their insatiable appetite for fuel, have thrown an effective block across that already hopeless road.

Even with our advanced aircraft and our improved techniques for operating them, our urgently needed global air force is beyond practical mechanical and economic reach. A bomber with a gross weight of 150,000 lbs. can carry a 10,000-lb. bomb load for 6,000 miles. To carry that same bomb load even 2,000 miles farther, demands an airplane of more than 300,000 lbs. gross weight. The fixed mathematical progression of size is truly frightening and discouraging.

Now, none of us fear size as such, but we are becoming increasingly aware of its limitations. Dr. Edward Warner has shown us that construction costs, for instance, increase in the ratio of 5 to 4 with size. In addition to this tremendous levy on capital, materials, and man power in the original construction stage, we must add proportionately increased costs of maintenance and handling, both aloft and on the ground. Bigger airplanes also mean bigger airports, and airport costs increase to astronomical proportions roughly as the square of the runway length.

It would appear, therefore, that we are suspended on the horns of a classic dilemma. On the one horn are the natural limitations imposed by further increases in size; on the other are the urgent demands for greater fuel capacity for the jet power plants.

To help us over this impasse we cannot hope for any major revolution in the design and construction of airplanes. Reduction in fuel consumption is of necessity a slow and laborious process. We are not likely to have any new, lighter metals at our disposal, nor can we change the laws that govern the aerodynamics of flight.

The more we study the problem, the more provoking becomes our acceptance of that initial penalty of 10 per cent demanded by the mechanics for getting the airplane off the ground and into its natural element. It is obvious that, if we could eliminate or reduce the conditions imposed by our acceptance of that "Kitty Hawk Compromise," we could take a long stride toward effective solution of some of the acutely limiting factors that now militate against achievement of greater operational efficiency.

Sixteen years ago, my associates undertook exploratory studies aimed at the discovery of a practical means of achieving the advantage inherent in the airplane's ability to carry more than it can lift. Those studies quickly centered upon the one element of load capable of being transferred to the airplane once it is aloft and in maximum carrying position. That was the fuel load.

There was certainly nothing new or revolutionary in that concept. Air-to-air refueling, in principle, is almost as old as flying itself. We have only to look back to the days of the "Question Mark" for a demonstration of its crude application. Its only generally recognized advantage, however, was its ability to increase the range of an airplane. This we could also accomplish by simply increasing the size of the aircraft. Through the years in which the reciprocating engine was mounting in horsepower and we could afford to employ size as a means of attaining our objectives for range, speed, and load, fueling in flight was relegated to the category of an interesting but academic speculation.

FIG. 1. Jet fighter refueling. Gloster Meteor taking fuel from a Lancaster tanker over the south coast during the 12-hour endurance record established on August 7, 1949.

Today, however, a demonstrable means of increasing speed, range, and load—no longer susceptible to solution by means of size alone—has become an economic necessity. As a result, over the past several years, major efforts in research and development have been initiated here, and intensified abroad, on the subject of in-flight fueling. Some notable progress has been made. We have now achieved a proved and practical means of fueling aircraft in flight.

CHARACTERISTICS OF A SYSTEM OF IN-FLIGHT REFUELING

I am not here to argue the relative merits of the various systems that have been developed or are projected to accomplish fueling in flight. It might be helpful, rather, to cite the characteristics that any such system must have if it is to be practical, qualifications that have grown out of more than a decade and a half of continuous study and experimentation in this field.

(*1*) *It must be safe.* Regardless of how an in-flight fueling system works, it must bring two airplanes in close proximity at relatively high speeds. The equipment, therefore, must be usable in such a way that any possibility of collision is remote. Whatever form of connection is used, an instantaneous and fully automatic breakaway must be possible at any time during the fueling operation.

(*2*) *It must be fireproof;* there must be no leakage of fuel.

(*3*) *It must be speedy.* This is particularly true for military operations. The advantages of speed in pressure refueling are equally applicable to civil aircraft.

(*4*) *It should be adaptable* to all speeds and altitudes of participating aircraft, capable of operating day and night and in all flyable weather.

FIG. 2. Complete hose drum unit in shop—starboard view.

(5) *It must be simple in operation.* It should not require special training or divert crew members of either the tanker or receiver airplanes from their normal flight duties.

(6) *The equipment should be light and quickly replaceable as a unit,* adaptable to a variety of configurations in aircraft, and capable of operating from any point in the fuselage, wings, or empennage.

(7) *Advantages in reversibility.* There are obvious advantages to a system that is completely reversible so as to permit refueling of the tanker in flight.

These are rather formidable specifications. I am particularly proud to be able to report, however, that most of these requirements have already been met. Continued and progressive improvements in existing techniques are being reported daily. Fuel is being transferred, as a routine operation, at the rate of 300 gal. per min.; 600 gal. per min. has been transferred experimentally. A system for the transfer of fuel to an aircraft at the rate of 1,200 gal. per min. is already well advanced. The same system, utilized for ground fueling, has demonstrated its ability to refuel large aircraft, as well as fighters, in minutes as compared with the hours required by standard systems currently in use.

It can be conclusively demonstrated, with systems available and in use, that in-flight pressure fueling is, today, a practical, safe, and economical method of supplying an airplane, in the air, with the energy it requires to stay in the air to the limit of its mechanical ability.

PRACTICAL APPLICATIONS OF IN-FLIGHT REFUELING

What are some of the practical applications of pressure fueling in flight?

It is a temptation to be dramatic about a mechanical development that can so singularly affect our long-standing concept of flight operations. It would be easy to fill the remainder of my allocated space here with documented proof showing the effect of in-flight fueling on airplane performance and utilization...on military strategy, tactics, logistics...on airport design and construction ... on safety ... increased economy ... efficiency...on some interesting applications to future aircraft design.

However, I would rather point to certain fundamental applications that seem to hold great promise, applications that may encourage you, in whose capable hands the future of our industry rests, to investigate further.

Such an investigation should be premised on the fact that in-flight fueling has more far-reaching effects than its obvious ability to extend the range of an airplane. By shifting the fueling operation from the ground to the air, where the airplane achieves its maximum efficiency, it opens up vast new areas. By directly attacking that basic 10 per cent penalty on efficiency, in-flight fueling offers several potentially revolutionary applications, of which increased range is only one.

Commercial Operations

Let us consider briefly only one phase of its effect on commercial operations. Obviously, the use of in-flight fueling on any particular route requires careful study if its proper advantages are to be capitalized. A study of world air routes, however, brings out certain facts of fundamental importance.

There is a basic still-air range of approximately 3,000 miles which supplies the key to successful operation of any major route. Today, such operations are marginal for even our largest and most advanced transport aircraft except under ideal conditions. By the use of in-flight fueling even standard aircraft can be operated over such ranges, irrespective of the total length of the routes involved. This means that, for any given pay load, the size of the airplane required for long-distance flights can be considerably smaller than one designed to cover those ranges nonstop without benefit of in-flight fueling. Further, by restricting the initial fuel load to a practical proportion of the gross weight, a substantially higher pay-load factor is available.

In general, half the gross weight of an airplane is available for useful load—that is, for fuel, crew, and accommodations—and pay load. When all of this disposable weight is given over to fuel, we get the maxi-

mum range of the airplane with zero pay load. Maximum pay load and maximum range are obtained when the fuel load equals one-half of the disposable load. Hence, we should expect the optimum distribution of disposable load to be as follows: 25 per cent fuel, $16^2/_3$ per cent pay load, $8^1/_3$ per cent accommodations.

Whenever we fail to attain such a pay-load percentage (roughly 17 per cent), we do so because we are forced to sacrifice pay load for range, which means for increased fuel. The only way by which we can extend range *without* losing pay load is by fueling in flight. By taking off with a fuel supply adequate only to ensure its first fueling operation aloft, however, an airplane can capitalize its added lift capacity for a substantial *increase* in pay load, reclaiming an important part of that "lost" 10 per cent.

By accepting fueling in flight, it is practical to design a transport airplane that can be used over all routes, regardless of range between intermediate stages, and which will also operate close to its maximum efficiency. Let us take a quick look at such an airplane and compare it, in our mind's eye, with those now in use.

To fly the North Atlantic route nonstop, carrying 50 passengers and normal complement of mail and cargo, our airplane would weigh approximately 100,000 lbs. gross and would use one refueling eastbound and two westbound. Assuming a 3,000-hour annual utilization, that airplane, with reciprocating engines, could make 114 round trips per year (126 with turboprops and 185 with jets), computing relative cruising speeds at 300, 350, and 450 m.p.h., respectively.

To accomplish a comparable nonstop performance without refueling in flight would require an airplane of some 250,000 lbs. gross weight, and its pay-load percentage would be only about 6 per cent.

But, you may naturally ask, what of the cost of a refueling operation? These costs obviously vary in accordance with the type of aircraft to be refueled. For the kind of operation we have used as an example, any standard airplane in the 65,000-lb. gross weight class would be suitable for a tanker. Practice has demonstrated that a maximum operating radius of 600 miles would be adequate for that tanker. Using the average air-line cost for an intermediate landing of about $19 per ton of gross weight, the cost of an air refueling would be approximately equivalent to one-half the landing cost of present transatlantic transport aircraft.

Other benefits—and they are substantial—are obtained without additional cost. Such benefits include the regular scheduled operation of long-range nonstop services, the value of which can only be partially reckoned in passenger time saved and increased aircraft utilization. There is a substantial saving in all capital and operating costs for both aircraft and airports. There are the benefits of greatly reduced wear and tear on the aircraft, of lightweight take-off and climb, of independence of weather conditions at intermediate stations, and of the avoidance of diversions due to unfavorable weather at alternate ports.

Finally, there is the immeasurable benefits from improved safety. By reducing the number of landings and take-offs required, we strike at the very source of 70 per cent of all aircraft accidents. On the North Atlantic route, for instance, in-flight refueling eliminates the necessity for two of the present three required take-offs and landings. Safety considerations, alone, would seem to justify adoption of in-flight fueling.

Military Aspects

In the military field fueling in flight has even broader applications. In considering this field we should keep in mind a fundamental difference in the economic employment of military as compared with commercial aircraft. In general, a commercial aircraft becomes productive once it becomes air-borne. On the other hand, the military airplane, with the possible exception of the military transport, is gainfully employed *only* after it is air-borne *and* has reached its operational area. A fighter must attain altitude and reach its target. A patrol bomber must first reach its patrol area. A long-range bomber must first reach the objective of its bombs.

This "portal-to-portal" penalty on endurance is graphically demonstrated in the jet fighter. Because of the fuel consumption characteristics of the jet engine, the take-off and climb to altitude, plus the return to ground for refueling, account for a large proportion of the endurance of the aircraft. By fueling in flight we immediately obtain a number of advantages for the fighter. Its effective load, in terms of armament and ammunition, can be greatly increased. Its take-off is lighter; its climb more rapid. Even in the simplest case—where the tanker plane is stationed over the home base—the fighter still gains the time otherwise required to descend, land, taxi to and from the refueling point, refuel, take off, and reclimb to altitude.

The possibilities in extension of range, for bomber support, and for ferrying over long distances are obvious. Also, in-flight fueling rescues the fighter from the too prevalent predicament of returning to an unusable base with insufficient fuel to carry it to a safe alternate.

In the case of bombers, generally, the bomb load $\times$ range factor is similar to the pay load $\times$ range factor cited in the case of the commercial airplane and the arguments in favor of in-flight fueling hold equally true. With bombers, too, we can halve our risks. On a mission that would normally require two bombers over the target, in-flight fueling will enable one bomber to carry the effective load of both planes, with the second bomber acting as the tanker. By this means the same bomb load is delivered to the target but the number of planes within that target area—the area of hazard—is reduced by half.

Conclusions

These are but incidents, cited at random. Applications of fueling in flight, and potential benefits to be

(*Continued on page 32*)

Progress in Stall Research*

GRAHAM CAMPBELL† and GIFFORD BULL‡
Cornell Aeronautical Laboratory, Inc.

Introduction and History

STALLING PHENOMENA HAVE BEEN STUDIED in various ways since the early days of the airplane. Considerable work was done by the British from the first World War to the 1930's, and, of course, the N.A.C.A. has investigated several aspects of the stall problem.

The British were concerned with the motion of the airplane and the effectiveness of the controls. They conducted analytical studies, as well as wind-tunnel and full-scale tests, and substantially all of the important concepts now commonly accepted may be traced to their early research. Thus, the change in sign of the damping in roll, the high induced angle of attack at the tips of tapered wings, the desirability of center-section stall, and the ineffectiveness of conventional ailerons were expounded, along with many other important basic conclusions. At the N.A.C.A. the details of the separation phenomena have been developed at some length by various investigators. The N.A.C.A. has also accumulated a large amount of experimental information on the stalling characteristics of various wings, the effectiveness of many types of controls, and much other valuable information on stalls.

These two main approaches to the stall problem—(1) the study of the overall motion and (2) the accumulation of detailed knowledge of the separate factors involved—have been complementary, but their close relationship has at times been overlooked. It seems safe to say that, while stalling phenomena are fairly well understood, the study of the dynamics of a stalled airplane is in its infancy.

With the knowledge at hand, it is now possible to build an airplane with excellent stall characteristics, but, unfortunately, many of the design features that improve the stall compromise some other desirable characteristic of the airplane. Designers are then faced with the problem of making the smallest concessions possible that will give good stalling characteristics in order to build an airplane that is satisfactory in other respects. The result is that, in general, the stall characteristics are made just good enough to be acceptable. Since there are many uncertainties involved, flight tests are necessary to see if the stall characteristics really are satisfactory. Obviously, some practical method of predicting with reasonable accuracy the motion of a stalled airplane would be of considerable value. With the increasing use of highly tapered, swept-wing aircraft, whose stalling characteristics are aggravated, it is increasingly urgent to be able to predict the stalled motions before a prototype is built and flown.

As far as minimizing the danger following a stall near the ground, it is important to control the pitch and roll attitude of the airplane even though flight path control is no longer possible. Improving the stall characteristics may result in better landing and take-off characteristics, since it would be safer to approach the maximum lift coefficient during these maneuvers. Some non-aerodynamic means (e.g., some form of automatic control or artificial stability) may prove to be the best all-around means of improving the stall characteristics. This might be particularly applicable to airplanes already equipped with artificial stability devices for other reasons, where these devices could be adapted for use at the stall. This would be an example of stabilizing by artificial means a basically unstable system or at least making it sufficiently less unstable to be readily controllable.

Recent advances in the study of the dynamics of unstalled airplanes suggested that perhaps the time was ripe for a renewed attack on the dynamics of an airplane at the stall, using modern electronic instrumentation and advances in mathematical techniques of handling dynamic systems.

The U.S. Air Force, as part of its handling qualities program, has become interested in determining the factors in the stall which are important to the pilots with the idea of setting up quantitative specifications for the motion of an airplane at the stall.

These objectives constitute rather a difficult task in the present state of knowledge of the stall, and before much headway can be made it is necessary to develop a method of predicting the motion of a stalled airplane from data available in the design stages of the airplane. Also, the method, if it is to be of practical value, will have to be reasonably simple to use.

The work done on the stall by Cornell, under a series of Air Materiel Command contracts, has been concerned with this basic study. This is one phase of the problem—i.e., developing a method of calculating the stalled motions. The other phase of the problem, not yet solved and not included in the present Cornell program, is quantitatively what can be considered good or bad stall characteristics.

Presented at the Session on Stability Control and Guidance, Annual Summer Meeting, I.A.S., Los Angeles, July 12–14, 1950.

* The authors wish to express their indebtedness to the sponsors of these studies: the Air Materiel Command, particularly Joseph Flatt, of the Aerodynamics Branch of the Aircraft Laboratory; the Boeing Airplane Company for the loan of the wind-tunnel model; the Fairchild Engine and Airplane Corporation for technical data; and the National Research Council of Canada for wind-tunnel data.

† Research Scientist.

‡ Associate Project Engineer.

If rational answers to each of these two aspects of the stall problem can be reached, then a designer at least has a quantitative idea of how good the stall characteristics of his airplane are in the design stages.

C.A.L. Approach

The Cornell approach to the stall problem has been a gradual one, first because of the complicated nature of the stall, and second to ensure that, in breaking down the problem into sections that could be studied separately, consideration of the overall problem was not lost. The stall motion is composed of several degrees of freedom, and consideration of any one degree of freedom or any one derivative, such as damping in roll, cannot be expected to define the overall motions of the airplane. The difficulty of conducting dynamic tests at the stall in the wind tunnel appeared so great that flight tests were indicated.

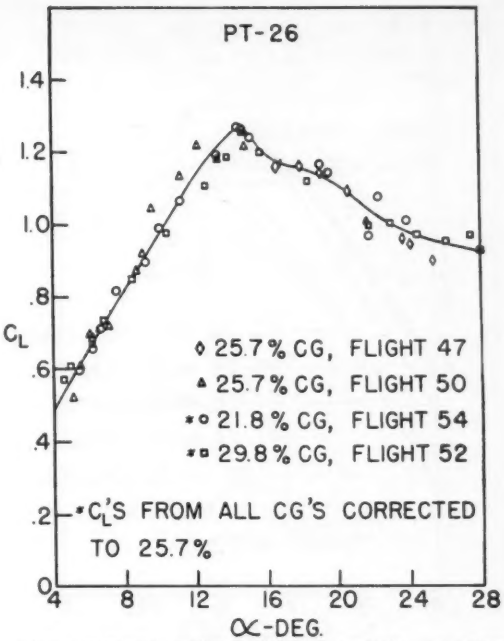
A Fairchild PT-26 airplane was selected as the test vehicle because it is a cantilever low-wing airplane of conventional design, wind-tunnel data were available on it, and it was economical and reliable enough to permit a large amount of flight testing to be conducted at a small cost. Its stall characteristics were "normal"—that is, not unusually bad—although when fully stalled it exhibited the usual violent roll-off.

Attention was first centered on the longitudinal motion in the stall. It was felt that it was probably simpler to handle than the lateral motion, and the primary variable that causes an airplane to stall is angle of attack, which is a longitudinal parameter.

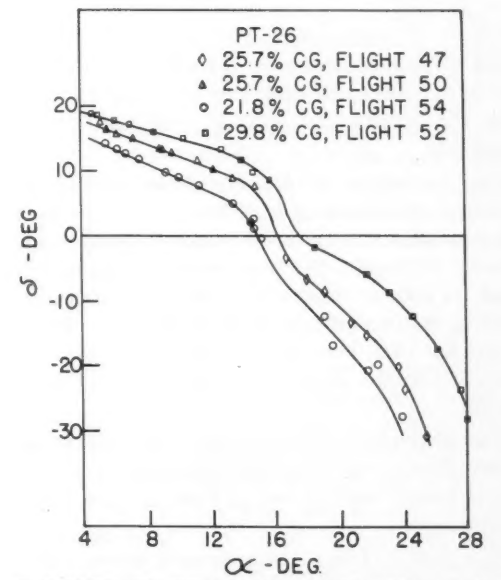
Exploratory flight tests showed that the lateral motion could be kept small in the stall, making it practical to study the longitudinal motion separately. Motion at the stall was also shown to be repeatable. The dynamic longitudinal motions of the airplane were observed to behave approximately as a mechanical spring-mass-damper system, and it seemed that linear second-order differential equations of motion could be used.

The airplane was then instrumented and flight tests were conducted which indicated that the theoretical approach was not unreasonable. The airplane was then modified to provide sufficient pitching moment to stabilize it in the stall and to provide better control over the initial conditions. The instrumentation was also improved to the point where accurate records of the important variables were obtained. Flight-test results, shown in Figs. 1 to 10, were taken in this phase of the program.

The assumption was made that linear equations could be used to describe the motion of a stalled airplane, as long as the displacements remain small. The restriction to small motions is not so severe as might be supposed, since the analysis yields usable results even for moderate motion; for divergent motions that rapidly become large, the fact that they diverge is often sufficient information. Furthermore, if the motions become large, the problem can be broken down into several



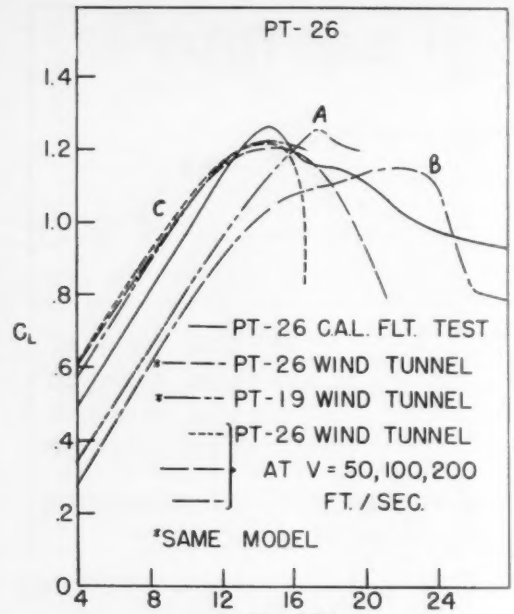
LIFT CURVE DETERMINED FROM FLIGHT
FIG. 1



ELEVATOR TO TRIM DETERMINED FROM FLIGHT
FIG. 2

stages, in each of which the motion is small enough to be handled by the small displacement methods. The end conditions of one stage are used as the initial conditions of the next, and the results are assembled to form a history of the motion.

Preliminary flight tests showed that the modified airplane, which would maintain steady flight at angles of attack well past the peak of the lift curve, was longitudinally stable in this region. Thus, control inputs could be applied, and the airplane would establish a new trim condition, with the motions remaining



LIFT CURVES FROM FLIGHT AND WIND TUNNEL
FIG. 3

small. The difficulty here, of course, was to keep the lateral motions small while this was going on to ensure that the longitudinal motions could be dealt with separately.

The assumption of linear equations implies constant stability derivatives, at least over some finite range of the variables, the primary variable being angle of attack. Obviously, the derivatives are not exactly constant (in fact, at times are anything but constant, depending on the past history of the motion). However, it was felt that, even in the stall, they could be considered constant over reasonable ranges of angle of attack.

The assumption of linear equations of motion, while rather drastic, simplified the mathematics so greatly that it seemed worth a try, at least as a first-order approximation.

As a matter of fact, the agreement between the calculated and experimental results was fairly good, as will be seen later.

The Test Airplane

The airplane used in these tests was a Fairchild PT-26, with the stabilizer made adjustable to 9° leading edge down. This modification provided sufficient pitching moment to allow steady glides at angles of attack up to 28°, which is 12° past the peak of the lift curve. At these angles of attack the airplane was fully stalled, and it was, of course, extremely difficult to keep the lateral motions small. It was found that, with practice and concentration, the pilot would keep the roll angles to less than 10° in about four stalled glides out of five. The stalled glides lasted up to 1 min., with the minimum safe altitude being the limiting factor.

The more important dynamic data were recorded on an oscillograph, while the secondary items and those of a quasistatic nature were recorded on a photo-observer. Angle of attack was measured by a vane-operated selsyn. The position error of this instrument was obtained in steady-state flight from the sum of geometric pitch angle and flight path angle, the pitch angle measured by a vertical flight gyro, and the flight path angle determined from air-speed and altimeter readings. Since steady-state stalled glides could be made, it was possible to obtain the angle-of-attack position error in stalled, as well as unstalled, flight.

The flight tests were conducted at approximately zero thrust to eliminate power effects as much as possible.

The lift curve and elevator-to-trim curves were determined in steady, stalled glides. The transient response of the airplane was determined by applying elevator step or impulse motions in a steady stalled glide and recording the incremental response around the stalled equilibrium condition. It was considered important to keep these incremental motions about a stalled trim condition small.

Wind-Tunnel Tests

In addition to flight tests, corollary wind-tunnel tests were made at the M.I.T. Wright Brothers Tunnel on a $^1/_5$-scale model of the PT-26. The tests covered three-component and six-component tests at angles of attack up to 30°, as well as dynamic pressure surveys of the wake in the vicinity of the tail and tuft pictures of the stall pattern on the wing and tail. Static longitudinal stability derivatives were computed from the wind-tunnel data for direct comparison with the flight-test results, and, in addition, wind-tunnel values of dynamic pressure in vicinity of the tail were used in reducing the flight data.

As a side remark, if most routine wind-tunnel tests were carried further above the initial stall, much additional information on stalling phenomena would be available. In this investigation we were constantly hampered by lack of any quantity of data above the stall.

Static Data

The static flight data were obtained from trimmed power-off glides in both stalled and unstalled flight at three c.g. positions.

The lift curve obtained in flight is shown in Fig. 1. The lift coefficients from the forward and rearward c.g.'s were corrected to the normal c.g. by subtracting the calculated difference in tail balance loads due to c.g. Then, the C_L's from all three c.g. positions were superimposed on one curve to determine the lift curve of the airplane.

It can be seen that the scatter at stalled angles of attack is not much greater than in the unstalled, al-

though, if the emphasis of the program were on unstalled data, some improvement below the peak of the lift curve might have been effected. The rates of descent at the higher angles of attack were large, ranging up to 3,600 ft. per min. These rates of descent correspond to drag coefficients greater than 0.4.

Fig. 2 shows the elevator-to-trim vs. angle of attack for the three c.g. positions. The unstalled portion plots as straight lines and shows the variation of both stability and trim as a function of c.g. The fixed-stick neutral point determined from these straight-line portions is 41 per cent, which agrees with the wind-tunnel data. The slope of the elevator-to-trim curve at any angle of attack or c.g. represents the ratio of static stability to control effectiveness for that condition.

As the stall is approached, separation starts inboard, causing the downwash in the vicinity of the horizontal tail to decrease. Two things then happen to cause the elevator-to-trim vs. angle of attack curves to deviate from straight lines. The wing wake in front of the tail rises to shield partially the elevator, decreasing elevator effectiveness. Also, the rate of change of downwash with angle of attack changes sign, increasing airplane stability due to the tail, since static stability due to tail = constant $\times$ $[1-(d\epsilon/d\alpha)]$. This decrease in elevator effectiveness with the increase in static stability causes a large negative slope. As the stall progresses spanwise, the downwash in front of the tail becomes less negative, causing a destabilizing influence on static stability, and the elevator-to-trim curve tends to flatten out. Also the wake begins to rise above the tail, increasing elevator effectiveness. Then, at still larger angles of attack, the trim elevator deflection is large, the effectiveness decreases, and the slope is extremely steep negatively. Note that steady-state angles of attack up to 28° can be reached at a c.g. of 29.8 per cent.

Notice that angle of attack is used as the index of static stability rather than lift coefficient. For dynamic stability considerations, α is a motion coordinate, C_L is not.

Both the lift curve and the elevator-to-trim curve prove that consistent data under steady-state conditions can be taken in the stall. These glides were made with the elevator locked. However, the pilot was continuously correcting the lateral and directional disturbances.

Fig. 3 shows lift curves for the PT-26 and PT-19 (aerodynamically similar) from several sources, three wind-tunnel and one flight test.

There are two types of inconsistencies in these curves. One is in the angle of zero lift. Curves A and B were obtained from the same model, and the angles of zero lift from the two tests agree when corrected for stabilizer incidence. However, they do not agree with the flight tests, the wind-tunnel tests (curves C), or N.A.-C.A. tests of the airfoil sections involved. The angles of zero lift from these three sources agree closely. The model was rechecked for alignment of thrust line and wing incidence and for wing twist, and the errors were

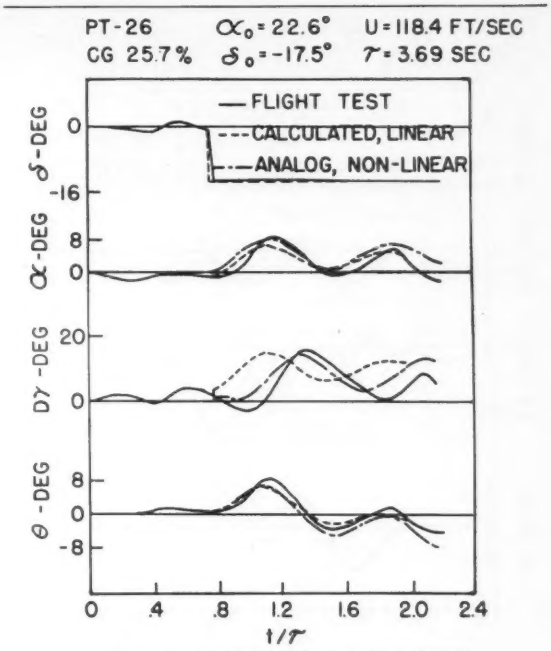


FIG. 4 RESPONSE TO ELEVATOR STEP

extremely small. This shift of approximately 2° in the angle of zero lift between the various tests is unexplained.

The most significant inconsistency is in the shape of the lift curve in the stall. This would seem to be largely a function of Reynolds Number. These data would indicate that quantitative information above the stall should come from tests of Reynolds Numbers approximating flight conditions.

Transient Data

The transient data were recorded as incremental motions about some trimmed reference. Power-off glides similar to those used to obtain static data were started, and, when a trim condition was reached, predetermined elevator motions were performed and the ensuing motion was recorded. This was done in stalled and unstalled flight.

At the unstalled angles of attack, the motion would quickly settle to a steady state. Analysis was possible by reduction of responses to periodic ones ($T/2$ of fundamental frequency equal to, or greater than, the time to reach steady state). By means of Fourier harmonic analysis, the frequency response curves are determined. The response of normal accelerations and angle of attack referred to elevator was determined in this way. These responses were plotted as polar circle diagrams as functions of frequency. An evaluation can then be made of equivalent stiffness, damping, and control effectiveness.[1]

The fact the airplane does behave as a second-order system, with the aerodynamic constants lumped into equivalent stiffness and damping terms, greatly sim-

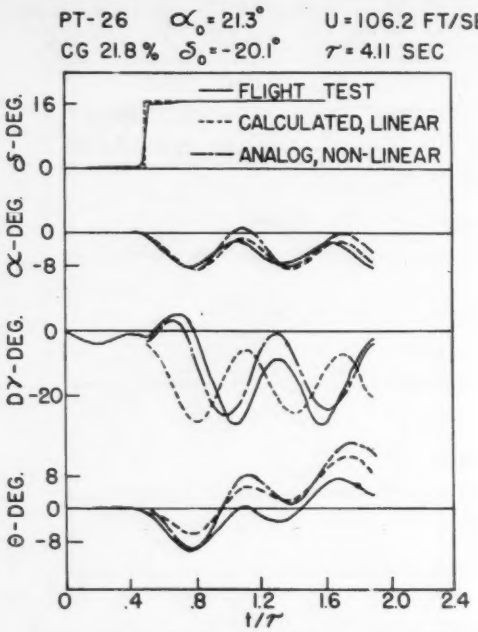


FIG. 5 RESPONSE TO ELEVATOR STEP

plifies the analysis. These lumped constants can be broken down into the various derivatives; lift curve slope, damping in pitch, static stability, and downwash. This data reduction process was done on a nondimensional basis, and measured moments of inertia were used.

For the stalled transients, Figs. 4 and 5, the responses take so long to reach a steady state that the harmonic analysis method is not practical. The airplane was stable longitudinally; thus, the disturbances could be kept small, and constant stability derivatives for the entire maneuver were justified. For these cases a curve-fitting procedure is used. In a lightly damped response, it becomes easy to detect the frequency of the oscillations. Also, from the envelope of the oscillations, the damping can be determined. Then, the steady state about which the response is oscillating can be determined.

Thus, the stiffness, damping, and control effectiveness were determined.

The analysis involved fitting the responses to the equations of motion and determining the derivatives. It was desired to keep the equations as simple as possible (perhaps oversimplified) and then determine how valid the simplifications were and include more terms as justified.

The initial equations used were equations of motion in two degrees of freedom, θ and α, because:

(1) Observed responses seemed to behave as linear second-order systems.

(2) An investigation using wind-tunnel data showed the phugoid to be unimportant. For the unstalled motion, the separation of the frequencies of the phugoid and short-period modes decreases as the air speed decreases. Calculations were made at angles of attack above the stall considering the speed change degree of freedom in addition to the two degrees of freedom considered in the previous calculations. Longitudinal stability derivatives determined from static wind-tunnel data were used. No appreciable effect on the period and damping of the short period was observed because of the inclusion of the phugoid mode.

Therefore, the assumption of constant air speed during the transient maneuvers is justified. As a result, the equations used were the summation of normal forces and the summation of pitching moments:

$$D\gamma = D\alpha - D\theta = z_w\alpha + z_\delta\delta$$

$$D^2\theta = \frac{\mu}{i_B} m_w\alpha + \frac{\mu}{i_B} m_{\dot{w}} D\alpha + \frac{m_q}{i_B} D\theta + \frac{\mu}{i_B} m_\delta\delta$$

Derivatives included are

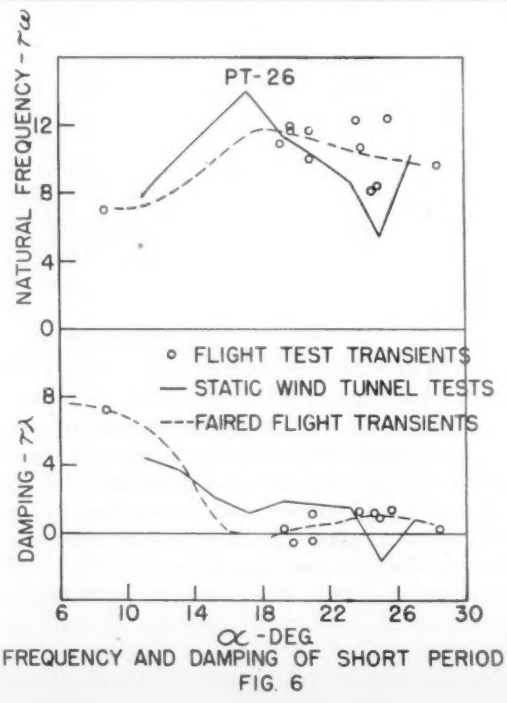
z_w = slope of lift curve
m_w = static stability
m_δ = control effectiveness
m_q = damping in pitch
$m_{\dot{w}}$ = lag of downwash
Also, the mass and moment of inertia in pitch

These simultaneous equations result in second-order equations with equivalent damping and stiffness terms.

$$\text{damping} = b = -z_w - (m_q/i_B) - (\mu/i_B)m_{\dot{w}}$$
$$\text{stiffness} = k = z_w(m_q/i_B) - (\mu/i_B)m_w$$

Particular integrals

$$D\gamma_{\text{steady state}} = (\mu/i_B)m_\delta(z_w/k) + z_\delta$$
$$D\theta_{\text{s.s.}} = (\mu/i_B)m_\delta(z_w/k)$$
$$\alpha_{\text{s.s.}} = (\mu/i_B)(m_\delta/k)$$



FREQUENCY AND DAMPING OF SHORT PERIOD
FIG. 6

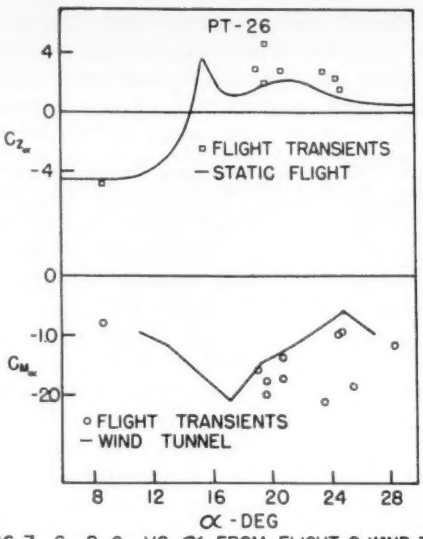


FIG. 7 C_{Z_α} & C_{M_α} VS α FROM FLIGHT & WIND TUNNEL

A typical response to a step elevator displacement, applied in a stalled glide, is shown in Fig. 4. The stability derivatives were determined from the measured period and damping of the response of the airplane and the steady state about which it oscillates. The derivatives were then put into the equations of motion. The motion predicted by the input used in flight is also shown in Fig. 4. The agreement between the experimental and the calculated curves is largely a measure of how well the linear equations of motion describe the physical situation and also of how accurately the derivatives were determined from the flight data.

$D\gamma$, the normal acceleration in the stall, is opposite in sign to unstalled responses (a pull on the elevator results in a downward curvature in the flight path). This is because of the negative lift curve slope, giving a smaller lift coefficient for an increased angle of attack.

Fig. 6 shows the roots, frequency, and damping, as determined from the transients. The frequency from forward -and-aft c.g.'s were corrected to the normal c.g. by determining the derivatives, correcting C_{m_α} for c.g., and then recombining the derivatives to form damping and stiffness terms and refactoring the quadratic. The damping is constant with c.g. Notice that the damping vs. α becomes negative and then positive.

Using this reduction procedure, Fig. 7 shows the values of C_{m_α} compared to wind-tunnel data, and C_{z_α} $[= -C_{L_\alpha}]$ compared to static data.

The last derivative determined in this reduction process is $d\epsilon/d\alpha$, which is evaluated by subtracting m_q/i_B and z_w from the total damping and assuming that

$$\mu m_{\dot{w}} = (d\epsilon/d\alpha)m_q$$

Fig. 8 shows the values of $d\epsilon/d\alpha$ determined from the flight transients and compared with the slope of the ϵ vs. α curve determined in the wind tunnel.

The transients in Figs. 9 and 10 (plotted dimensionally) show the variation of damping with α. The procedure was to trim as close to $C_{L_{max.}}$ as possible from the unstalled side and apply an elevator step to cause the airplane to stall. Less than full back stick was applied in the maneuver of Fig. 9. The undamped oscillation of 4° amplitude in angle of attack (centered about $\alpha = 17.5$) means that the damping coefficient is zero or negative for some angle of attack region smaller than 4° centered about $\alpha = 17.5$. This information was used in fairing the damping vs. α curve in this region, since no steady-state glides were recorded, because with

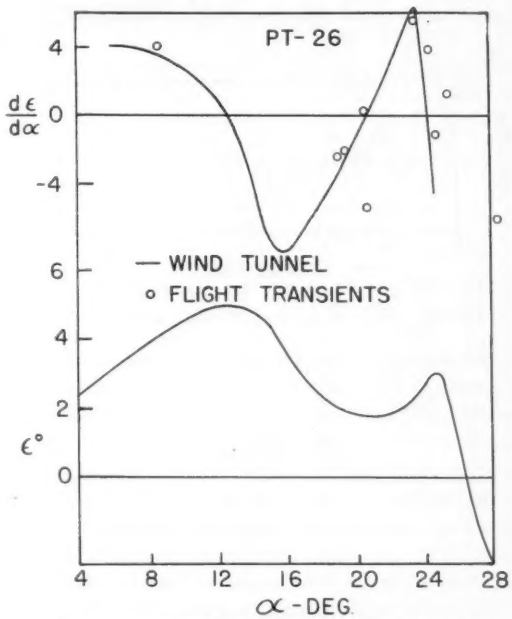


FIG. 8 DOWNWASH DETERMINED FROM FLIGHT & WIND TUNNEL

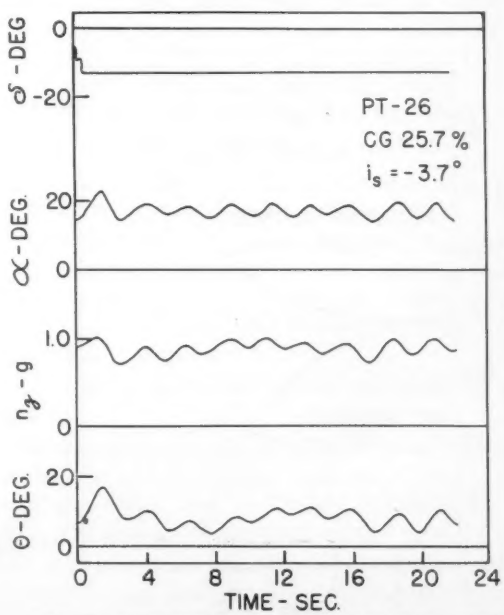


FIG. 9 RESPONSE TO ELEVATOR STEP FROM UNSTALLED INITIAL CONDITIONS

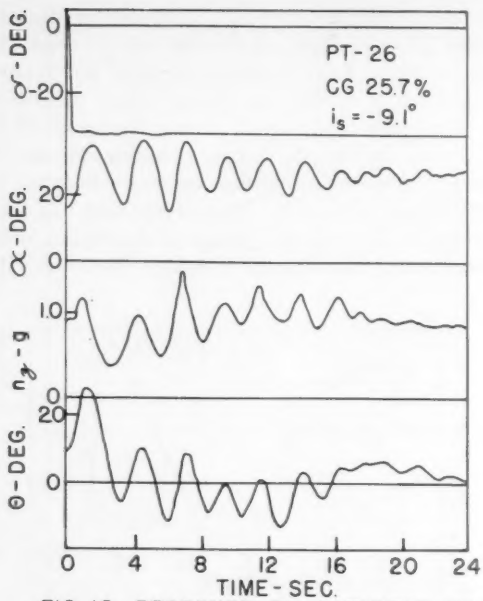
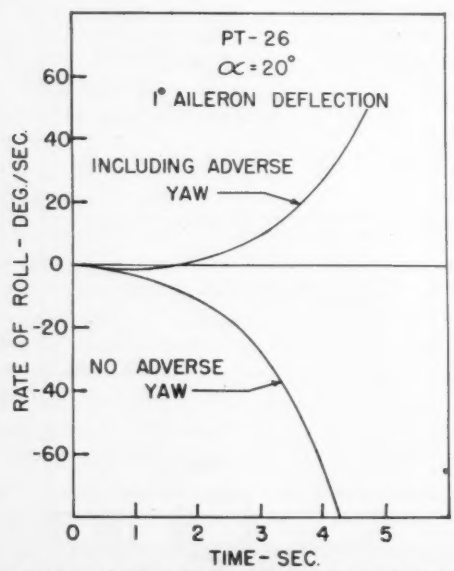


FIG. 10 RESPONSE TO ELEVATOR STEP FROM UNSTALLED INITIAL CONDITIONS

negative damping, the transients do not die out. A few points of the static lift and elevator-to-trim curve were obtained by measuring the mean about which the aircraft oscillates. The response of Fig. 10 was obtained by applying full back elevator. It can be seen that the airplane reaches an angle of attack higher than that of Fig. 9 and that, although the damping is light, a reasonably steady-state condition is eventually reached. The steady-state angle of attack in Fig. 10, about 26°, is in the stable region of damping vs. α shown in Fig. 6.

Agreement between the experimental and calculated motions in Fig. 4 is excellent, except that there is a lag of about 1 sec. in the experimental value of the normal acceleration.



CALCULATED RATE OF ROLL DUE TO AILERONS
FIG. 11

Fig. 5 shows a similar response except in the other direction. The same type of lag of normal acceleration behind angle of attack appears, showing this lag is not a function of angle of attack or pitch but probably of time.

After examining these responses, the equations were set up again, introducing a time lag in the wing lift derivatives, making them proportional to angle of attack at constant time previous, rather than present time ($t-a$ rather than t). These nonlinear equations, no longer simply handled analytically, were solved on an analog computer at the Office of Air Research at Wright-Patterson Air Force Base. Such a form of the equations resulted in excellent agreement with the observed flight results, including the time delay in $D\gamma$. The numerical values of the derivatives used on the analog had to be changed to maintain the correct frequency and damping, indicating that the initial values obtained by means of the simplified equations were somewhat in error. Figs. 4 and 5 also include the analog responses.

Lateral Motion

Most of the work on the stall done by Cornell to date has been on the longitudinal motion. However, an analytical study was made, using linearized equations of motion, of the lateral motion of a stalled airplane. Calculations were made of the response of the airplane to some arbitrary input and to control motions representing an attempt to recover level flight after a disturbance. The results appear qualitatively correct, although no flight-test figures are available to get a quantitative check. It is often said that the aileron effectiveness reverses sign in the stall. Actually, in the stall, conventional ailerons usually still produce a rolling moment in the desired direction. The difficulty is that they also produce a large yawing moment, which in turn produces sideslip. The dihedral effect, or rolling moment due to sideslip, is large above the stall, and the resulting rolling moment, which will be in the wrong direction, may well be larger than that due to ailerons. The result is that the airplane starts to roll in the desired direction and then reverses and rolls the other way. Since the damping in roll of a conventional wing is negative above the stall, the rate of roll builds up rapidly. This effect is shown in Fig. 11. If sufficient rudder were applied to counteract the yawing moment due to aileron deflection, the sideslip could be kept zero, and this effect would not appear. Furthermore, the rudder could be used as a roll control. Fig. 12 shows some calculated roll responses to rudder displacements. It was assumed that the rudder was moved an arbitrary amount and, then, after a time delay, was moved in a direction to reverse the motion. The importance of the delay in reversing the control is shown in this graph. This effect is well known to pilots, who find that it is possible to control a stalled airplane in roll by using the rudder but that any delay in moving the rudder is critical.

Since automatic controls can often be made to have smaller lags than occur in manual control, the possibilities of using an automatic control to prevent the airplane from rolling off were investigated using the assumption of linear equations of motion of the airplane and approximating the lag of the autopilot. Several plausible autopilot systems were analyzed, and it was found that an autopilot moving the rudder proportional to a combination roll angle, roll rate, and roll acceleration signals would result in stable motion of the airplane for certain ranges of sensitivity. A plot of the stability boundaries, indicating conditions of roll rate and acceleration sensings applied to the rudder that give stability for a given displacement sensing, is shown in Fig. 14. Only a few systems were investigated, and it is probable that other combinations of signals would also do the job.

Lateral Experiments

For the sake of simplicity, it was desired to study the longitudinal and lateral motions separately. After considerable practice the pilot was able to keep the lateral motions small during the trimmed glides in the stall to establish the lift curve. In these glides the elevator was locked, but the ailerons and rudder were constantly moving to keep the lateral motions small (see Fig. 13). Usually, the pilot was able to maintain a bank angle between $\pm 10°$, often less. The PT-26 is not stable laterally in the stall, and careful piloting technique with much practice was necessary to prevent the airplane from rolling off. When flown stalled with fixed controls, the airplane will never remain in equilibrium longer than a few seconds, diverging rapidly in roll if disturbed.

As a result of lateral instability in the stall, the technique of maintaining static equilibrium and recording

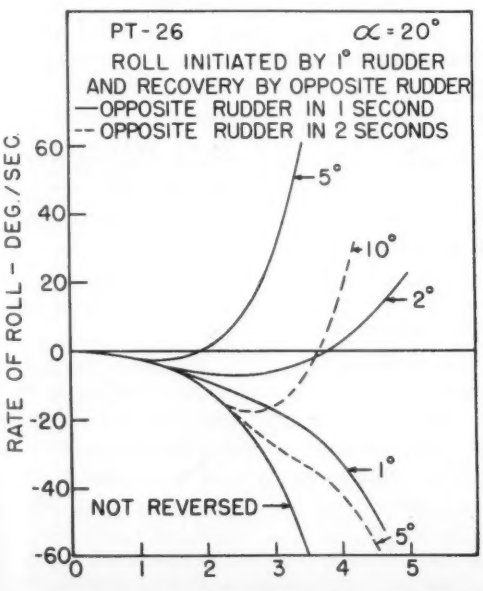
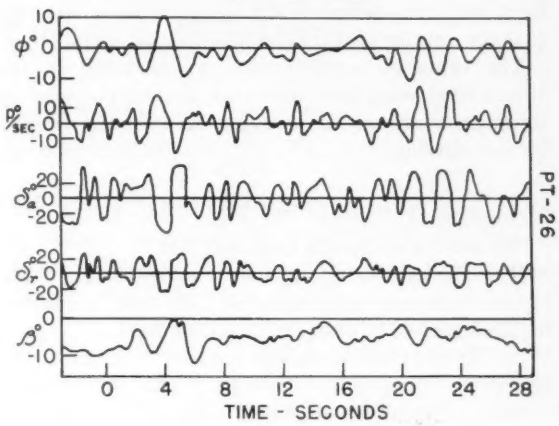


FIG. 12 CALCULATED ROLL RESPONSE

FIG. 13 LATERAL MOTIONS IN A STEADY STALLED GLIDE



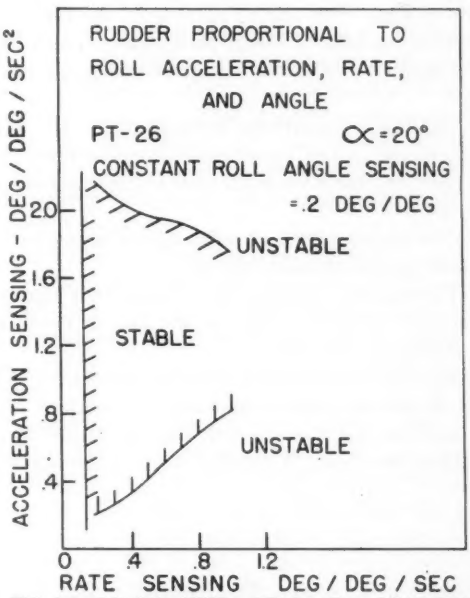


FIG. 14 CALCULATED STABILITY BOUNDARIES

small deviations around this equilibrium, as used in studying longitudinal motions, will not be applicable.

Since the pilot can do a passable job of keeping the wings level in stalled flight, it seems reasonable that an automatic pilot could do a better job. Accordingly, at present, an automatic pilot is being installed in the Fairchild test airplane.

The aileron and rudder will be automatically controlled.

When progressing from unstalled to stalled flight, the derivatives whose changes most affect the motion, making it violent and hard to control, are l_p, N_p, and N_{δ_a}. The sources of automatic control signals will be primarily roll angle, rate, and acceleration. Aileron position as a signal to the rudder will also be used.

Control by rudder alone, as well as combined aileron and rudder control, will be tried.

The objectives of the lateral program will be (1) to determine the lateral aerodynamic derivatives in stalled flight and (2) to determine the optimum autopilot setup to make a stable airplane-autopilot combination.

The types of aerodynamic lags discussed in the longitudinal wing derivatives are also encountered in the lateral motions. An analog setup will likely be used for calculations.

Conclusions

The studies at Cornell indicated that:

(1) The motion at the stall was repeatable, if the initial conditions were repeated, and that consistent flight data could be obtained in stalled flight.

(2) It was possible, though not easy, to separate the lateral and longitudinal motion at the stall, which greatly facilitates the analytical study of the motion.

(3) Linear equations of motion were shown to give a reasonably good first approximation to the measured longitudinal motions of the airplane, except for a time delay of about 1 sec. in the measured normal accelerations.

(4) Nonlinear equations incorporating this time delay were easily solved on an analog computer and give good agreement between calculated and measured motion.

(5) The physical reason for this rather large time lag is not now completely understood.

(6) Preliminary calculations indicate that the test airplane can be made stable in the lateral mode by means of automatic control.

Considerable work remains to be done before it will be possible to predict with confidence the motions of a stalled airplane, but it is believed that the method of attack outlined is sound. A detailed study of the complex aerodynamic phenomena that occur when airflow changes from the unstalled to the stalled régime is certainly worth while for an exact understanding of the stall, but the difficulties of such studies must not be allowed to obscure the fact that the important consideration is the resulting motions of the airplane and what can be done about them with the controls. Lack of complete understanding of all the detailed phenomena involved in the stall should not prevent the rational use of all available information. A continuous matching of the most up-to-date theoretical and empirical knowledge with this prime consideration of the motion is essential for a rational understanding of the stall problem.

Reference

[1] Milliken, W. F., Jr., *Progress in Dynamic Stability and Control Research*, Journal of the Aeronautical Sciences, Vol. 14, No. 9, p. 493, September, 1947.

Bibliography

[1] Weick, Fred E., and Jones, Robert T., *The Effect of Lateral Controls in Producing Motion of an Airplane as Computed from Wind Tunnel Data*, N.A.C.A. T.R. No. 570, 1936.

[2] Jones, B. M., and Trevelyan, A., *Step by Step Calculations upon the Assymmetric Movements of Stalled Aeroplanes*, British A.R.C., R. & M. 999, October, 1925.

[3] *The Lateral Control of Stalled Aeroplanes*, Stability and Control Panel of the British A.R.C., R. & M. 1000, 1925.

[4] Campbell, G., and Whitcomb, D. W., *Theoretical and Experimental Investigations of the Longitudinal Stall Dynamics of a Conventional Airplane*, C.A.L. Report TB-498-F-1, May, 1948.

[5] Campbell, Graham, and Bull, Gifford, *Determination of the Longitudinal Stall Dynamics of a PT-26 Airplane*, C.A.L. Report TB-498-F-2, February, 1950.

[6] Campbell, Graham, and Bull, Gifford, *Analytical Investigation of Lateral Motions of an Airplane at the Stall with and without Autopilot*, C.A.L. Report TB-556-F-1, April, 1949.

The Application of Pressure Refueling to Flight

(*Continued from page 23*)

derived therefrom, are as varied as the uses to which aircraft can be put. The few examples mentioned, I hope, will serve to indicate the tremendous breadth of the field that opens in the full development and utilization of this new technique.

I appreciate, too, that this is much too hasty, much too casual a presentation of the subject. The records are open; the facts and figures are available to you. And if, in this brief discussion, I have stimulated your interest and encouraged your own investigation of those facts and figures for their potential application to some of the major problems with which you, as engineers, are concerned, my purpose will have been accomplished.

That fueling in flight represents a challenge there can be no doubt. How important that challenge is was voiced by the late General of the Air Force Muir S. Fairchild when he said:

> "The ultimate effect of air refueling on air operations may be fully as profound as the effect of the development of sea refueling techniques on naval operations."

In that significant statement is also expressed, I feel, the promise that, in the technique of fueling in flight, those upon whom we depend for aviation's continued advance will discover one more instrument with which to mold aviation as man's most economical means of major transportation—as the world's most effective power for peace.

Problems Related to Airworthiness Requirements for Commercial Turbine-Engined Airplanes

GEORGE W. HALDEMAN*

Civil Aeronautics Administration

Introduction

In attempting to discuss the problems relating to airworthiness regulations for commercial turbine-engined airplanes, I do not want to leave the impression that we in the C.A.A. feel that we have or know all the answers. Rather, I would prefer to attempt to present some of the problems as we see them as a result of our study of certification and operational problems that will be encountered in operating high-altitude, high-speed, turbine-powered aircraft.

Desiring to keep abreast of the development of high-speed, high-altitude flying aircraft and the new problems that would be presented in the operation of such aircraft, we in the C.A.A. started some 2 years ago to make a scientific study of these problems in order that we could present them to the industry as a basis for general discussions of regulation requirements and a development of technique in conducting Type Certification tests.

Each of the branches of our Aircraft Division were asked to prepare the results of such a study to be incorporated in a general symposium within our own Aircraft Division for an exchange of points of view on the various problems. As a result of this symposium, we attempted to categorize the major items that needed discussion and agreement between the Government aeronautical agencies and the industry. The results of this symposium have been prepared in an Aircraft Division report, which is now being circulated among the aircraft industry. I will attempt, here, to discuss some of the more important items.

I should like to state that technicians of our Division have been working closely with the American manufacturers who have been producing military turbine-powered aircraft. It has been our good fortune to extend our study to include a certain degree of participation and discussion with the manufacturers and certificating agencies of foreign governments presently producing turbine-powered transport-type aircraft. This includes the Vickers Viscount, equipped with four turbine-propeller engines; the converted DC-3 with two Mamba-powered engines; the A. V. Roe C-102 jet liner; and, most recently, the de Havilland Comet. Recently, I had the opportunity of participating in two flights of the de Havilland Comet of approximately 4 hours' duration, and I should be less than fair to the British and the de Havilland company if I did not state that I was duly impressed. Naturally, some of the thinking to be revealed here will have been influenced, to a certain degree, by observations and experiences gained from flying these aircraft.

In the field of commercial transportation the goal of the air lines has always been increased speed, provided it could be obtained without sacrifice in safety, comfort, reliability, and economy. This basic desire has led us to the turbine engine as the next logical step in transport development. The consensus is that this "new" type of civil aircraft will be of unusual design as compared to our present types. All of you are familiar with the eventual configuration changes that will be involved but I feel it appropriate at this time to list those major items that we feel will conditionally affect the regulations that will be proposed by C.A.A., these being sweepback, thin wings, and, of course, the turbine engine.

Such configuration changes will bring about operational characteristics that are completely strange to civil-type aircraft. As previously mentioned, they will fly faster (our basic reason for adopting this type); higher fuel consumption will result with turbine power plants, and higher operating altitudes must be adopted to relieve this thirst for fuel. These changes should cause no apprehension, since a sound and rational understanding of the overall subject will permit safe and effective treatment of any problems that may arise.

A survey of the information and data available points out a lack of operational experience for the basis of our study. Since safe operational procedures, as well as airworthiness, are an important part of all air regulations, the logical solution would be a civil operational test program or service test, possibly with a modified military jet airplane. This program should necessarily be an exacting study to determine optimum procedures of operation for civil jet transports.

However, prior to such a program we must study the overall subject and attempt to isolate the problems that will surely develop. With the present knowledge of the idiosyncrasies of turbine-driven aircraft, many of these problems can be brought to light. Thereby, a rational approach to their solution can be undertaken and eventually solved, while others must be left to development during the process of certification and operational test programs.

Here, I will attempt to categorize those problems that C.A.A. recognizes as the most pertinent to these specialized operational procedures. In this way we hope to stimulate discussions with industry and the operators so that our obligation can be resolved ex-

Presented at the Session on Turbine-Powered Aircraft, Annual Summer Meeting, I.A.S., Los Angeles, July 12–14, 1950.

* Chief, Aircraft Division.

peditiously. An attempt is made to indicate the possible solution or choice of solutions that may be applied. We do not claim to know all the answers. These problems are discussed as briefly as possible so that we may cover as great a latitude as space permits.

The higher operating speeds will necessitate a re-evaluation of the structural design criteria required in the present Civil Air Regulations. It is, therefore, appropriate to begin this technical discussion with those regulations that govern the design of the air frame and its associated equipment.

Aircraft Structures

Design Flap Speeds

The large spread between normal operating or cruise speeds and landing speeds expected in jet aircraft and the current tendency of operators to approach landing areas at speeds approaching or exceeding design flap speeds indicate that current design speeds may be unconservative for jet types. It is the opinion of C.A.A. that the design speed for flaps used as high lift devices should be selected by the designer but should probably be not less than $1.8V_{S_1}$. This spread between stall speed and design flap speed should be sufficient to account for cases where the flaps are to be used for high lift devices alone.

Design Speed for Maximum Gust

For present aircraft, this speed is intended as the safest speed for flight through rough air. It is defined as the speed at which the line for maximum design gust intersects the maximum lift line. The significance of V_B as a design speed at altitude as now defined in Part 4b must be carefully reconsidered, since at high altitude, because of deterioration of $C_{L_{max.}}$ with increasing Mach Number and because of the increase in the slope of the lift curve due to compressibility, the maximum lift line might fall below the maximum gust. A definition of V_B in terms of an intersection would therefore be inadequate. The spread between V_B and V_C should realistically account for the time required to slow the airplane from this cruising speed to the rough air speed and for the rate of increase to V_C in the event of upset at V_B from the rough air.

Cruising Speed

Actual operating cruising speeds for jet-powered aircraft will closely approach maximum possible level flight speeds. Since some margin is necessary between design cruising speed V_C (the speed at which a 30 ft. per sec. gust could be structurally satisfactory) and actual operating cruising speeds, it appears desirable as a minimum to relate V_C directly to airplane performance. The designer should select the value of V_C for his design, but this choice should be sufficiently large to encompass the spread between V_B and V_C discussed previously and should be consistent with the actual performance of the airplane. It is thought that V_C should at least be equal to the speed corresponding to continuous cruising power, plus a possible increment of Mach 0.05.

Design Dive Speed

The spread now specified between design dive speed V_D and design cruising speed V_C will possibly severely handicap the high-speed jet aircraft. It appears that for aircraft having designed dive-speed Mach Numbers of less than 0.65 no change over present V_C and V_D relationships seems necessary. For over Mach 0.65, a margin between V_C and V_D adequate to ensure that the design dive speed will not be exceeded in operations seems warranted. The amount of spread required should take into consideration provisions incorporated or inherent in the design to limit speed. For instance, unless drag rises sufficiently to limit speed increase to a lesser value, perhaps a Mach Number increment of at least 0.10 should be retained.

Maneuver Envelope

The high speeds of operation of jet-powered aircraft will make mandatory larger turning radii, and maneuverability will thereby be lessened. However, if operations are carefully controlled no increases in maneuvering load factor may be necessary; otherwise, an increase of the present 2.5g minimum value for design is inevitable. Experience also indicates that compressibility effects, with associated changes in loadings of wings and control surfaces, must be evaluated for each design; therefore, investigation of effects of altitude and speed will probably be necessary. Deterioration of maximum lift coefficient and variation of other aerodynamic parameters will probably make it impossible to realize a load factor of 2.5 at, say, a 40,000-ft. altitude; therefore, it may be desirable to investigate for only those load factors that can be achieved in conjunction with buffeting loads.

Gust Envelope

The gust values in the present regulations have evolved from flight measurements and have proved appropriate to scheduled air lines operating up to 20,000 ft. and in all climates and over all terrain. When flight at altitudes considerably higher than 20,000 ft. is considered, there has been some hope that these altitudes would amount to flying above the weather.

Recent reports indicate, however, that severe gusts have been encountered at high altitudes (40,000 ft.) and that some of these were encountered in clear air. Although these reports are isolated, they raise a serious question as to the advisability of utilizing statistical methods as a basis for reduction of gust-strength criteria. Until more information is available, it appears advisable to consider that the gust magnitudes are the same as are specified for sea level with no reductions or modifications for the effect of altitude.

Aside from the question of variation of gust intensity with altitude, it may be advisable to increase the gust

magnitude at V_D to perhaps $22^1/_2$ ft. per sec. because of the greater proportion of time spent near the maximum structural cruise speed. Naturally, the effects of compressibility are expected to be considered in the computation of gust loads.

Substantiating Aerodynamic Data

In the past, it has not been necessary to require that specific wind-tunnel test data be obtained for a proposed airplane, since general aerodynamic data have been satisfactory. This attitude may require modification in the case of the high Mach Number airplane, since the difficulties of predicting compressibility effects and the greater importance of small and local changes in configuration indicate that specific wind-tunnel test data may be required as a minimum to determine design air loads.

Flight Demonstrations of Maneuver Envelope Limits

Although a high-speed aircraft may have satisfactory unaccelerated flight characteristics, the aircraft when subjected to accelerated flight may develop handling characteristics of an unsatisfactory nature or may encounter critical loading or vibratory conditions. These possible adverse conditions are most difficult to predict analytically, and structural flight tests of the various limits of the V-G envelope to be explored at various altitudes may be necessary.

In case it is impractical to demonstrate the design envelope in flight because of buffeting, deterioration of flight characteristics, etc., it may be necessary to consider an *operating* V-G envelope. The minimum permissible boundary of this envelope will require thorough and careful study.

Aircraft Equipment

Automatic Speed Control Flaps

The hazards involved in exceeding design or demonstrated air speed make consideration of an automatic speed-control flap mandatory. Because of its inherent aerodynamic cleanliness and the small expected margin between normal operating cruising speeds and never-exceed speed limits, the high-speed airplane will, quite likely, frequently approach or exceed design never-exceed speeds unless some provisions are made in the design to automatically limit inadvertent speed pickup. Dive-brake-type speed-control flaps offer a solution to this problem. However, they must be capable of either being operated quickly by manual means or must operate automatically within an extremely short period at a specified speed. Any device provided should be capable of operating, or being operated, with full effectiveness within 5 sec. of the occurrence of the disturbance making operation necessary.

Brake System

Since climb-out speeds will be higher, discontinued take-offs will require better brakes and braking systems. Inasmuch as reverse thrust to augment braking will probably not be available, deceleration will generally depend completely upon the brakes plus supplementary means of stopping the airplane. At high speeds, the coefficient of friction falls off rapidly, and at the same time a considerable amount of the airplane weight is taken by wing lift. This results in skidding of the tire, which further reduces the effectiveness of brakes. It may be desirable to require that a suitable antiskid device be incorporated within the brake mechanism. It also may be necessary to require two braking systems independent of each other, particularly if some supplementary means of braking is not used.

Emergency Exits

Concerning emergency exits and securing of exits, rapid evacuation of aircraft occupants is a goal to which considerable effort should be devoted. Speed in evacuation is of paramount importance, and to accomplish this larger openings are needed. Generally speaking, it appears that a few large openings are better than many small ones. A definite time limitation for evacuation appears in order (possibly 1 sec. per person and/or the total time not to exceed 1 min.) because the progress of fire is always rapid regardless of the size of the airplane.

Recent experience has emphasized that positive securing of all doors and emergency exits is considered essential. To accomplish this it may be necessary to require that all exits open inward to prevent any possibility of their opening in flight due to pressure differences. Inward opening doors and emergency exits could adversely affect the ability to get out of an airplane. To ensure quick evacuation, the area at the exits should be clear and without interference of any kind.

Oxygen System

The present supplementary oxygen regulations for pressurized cabin aircraft are inadequate relative to the supply and use of oxygen at altitudes above 25,000 ft. In the event of explosive decompression at altitudes above this height, all crew members and passengers must be immediately supplied with oxygen in view of the serious effects of anoxia at these high altitudes. Three possibilities of coping with the problem are evident at the present time; these are:

(1) All passengers can be supplied with oxygen masks and instructed in the use of the equipment prior to entering altitudes above 25,000 ft. This possibility has the disadvantage of having a poor psychological effect on the passengers.

(2) Consideration can be given to the flooding of the passenger compartment with oxygen. This may be impractical at extreme altitudes in view of the large amount of oxygen which would have to be carried to accomplish the objective.

(3) It might be feasible to make the aircraft structure reliable enough so that it is impossible for an ex-

plosive decompression to occur, in which case it would not be necessary to carry any additional supplementary oxygen breathing equipment over that now required.

As additional data becomes available, the best of these possibilities will become evident.

Power Plants

The next general item that will be discussed is aircraft-engine airworthiness. To date, there have been four turbine engines certificated for civil use. The various aircraft-engine manufacturers have at least six more turbine engines that are being readied for ultimate civil use. As provided for by the Civil Air Regulations, the turbine engines approved so far were approved on the basis of complying with the existing military requirements contained in Military Specification MIL-E-5009, or the superseded requirements contained in Army-Navy Aeronautical Specification AN-E-32. That the AN-E-32 specification only enjoyed a life of 3 years before being superseded by the MIL-E-5009 specification, which latter specification contains much stiffer requirements as dictated by previous service experience acquired, emphasizes the fact that the turbine engine power plant is definitely a new generic type of power plant with a host of new problems peculiar unto itself. The last 5 years have witnessed tremendous improvements and significant modifications to the current crop of turbine engines. It is anticipated that improvements of a significant nature will continue to be made to these engines but on a constantly decreasing spiral. It is known that the military services and privately sponsored research organizations are studying practically every phase of the basic turboprop and turbojet engines in an endeavor to increase their reliability and durability along with schemes and devices to improve their thermal efficiency and operational flexibility. Civil requirements are being readied for industry's use consistent with (1) the proposed requirements presently being studied for inclusion in ICAO's Standards and Recommended Practices governing Airworthiness of Aircraft applicable to engines; (2) existing military requirements; and (3) the service experience being attained with current turbine engines powering aircraft now in operation. Inasmuch as there are so many turbine power-plant problems that could be discussed, only the more important problems and the issues relating thereto are discussed here.

Turbine Acceleration

Although it is possible to accelerate conventional (reciprocating) engines from idling to maximum continuous speed in 3 sec. or less, the turbine engine [because of (1) the inertia of its moving parts, (2) greater speed range, and (3) peculiarities of the turbine cycle] requires 12 to 15 sec. to accomplish the same thing. Quick acceleration is a desirable feature, especially in the abortive landing procedures, and must be catered to. This problem can be brought under control by use of special devices, specific operating instructions, and/or applicable demonstrating tests.

Thrust Augmentation

Thrust of turbojet engines under static conditions is relatively low when compared with the thrust generated by the propeller-engine combination, thereby affecting take-off performance of this type of turbine engine tremendously. Consequently, some means of thrust augmentation is warranted in order to cater to poor take-off performance of this engine. Two means that are currently available are via (1) tailpipe burning or (2) water-injection or Jato-type assist. The degree of thrust improvement and successful application of the first two of these methods is being diligently pursued by N.A.C.A., the military services, and industry. In addition, civil turbine requirements are being developed to allow the use of these methods to assure satisfactory airworthiness.

Blowouts and Relighting Problems

Experience has shown that the phenomenon of complete combustion failure (blowout) occurs with increasing frequency as higher altitudes are attained. This is particularly serious because combustion can only be restored by either markedly decreasing the speed of the aircraft or descending to a much lower altitude. Indications are that this problem will be resolved by (1) improved combustion chamber design, (2) variable-area fuel nozzles, and (3) more appropriate fuel to permit higher combustion efficiency at altitude.

Durability, Reliability, and Overhaul Periods

The first and most important characteristic that must be demonstrated by turbine engines is their degree of mechanical reliability. In this regard, durability may be defined as the measure of engine life obtained while maintaining this desired reliability. It must be shown definitely that turbine power plants will function reliably between overhaul periods, with the chance of a complete breakdown being remote. With the introduction of such power plants in civil aviation, it is essential that initial overhaul periods be established on a conservative basis. Increases in established overhaul periods should be made only when adequately justified by service experience.

Fuel Tanks

Because of the low thickness ratio of the wings of high-speed airplanes and the high fuel consumption of jet engines, it may be difficult, if not impossible, to store the majority of the fuel load in the wings as has heretofore been done on conventional transport airplanes. Storage of a substantial quantity of fuel in the fuselage is generally acknowledged to be more hazardous than storage that is more remote from the inhabited portions of the airplane if there is a likelihood of fuel-tank rupture and fuel ignition in a moderate crash. Consideration will be given to including in the regulations a re-

quirement that all fuel be carried as remotely as possible from the fuselage or that, if fuselage fuel tanks are installed: (a) they be protected from damage or puncture in a crash landing by interposing substantial protective structure between the tank and the exterior of the airplane; (b) fuselage tanks be capable of withstanding without failure any loads resulting from the accelerations occurring in a crash in which passengers could be expected to survive (the feasibility of a figure of at least 20*g* should be investigated); and (c) they be sufficiently isolated and ventilated.

In view of the crash fire hazard associated with high contact speeds and greater fuel loads, it is suggested that serious consideration be given to restricting jet airplanes to the use of low-volatility fuels in view of the jet engines' ability to use these fuels readily.

Icing

Control of the icing problems on turbine engines appears more difficult to achieve than on reciprocating engines. Projections and supports within the intake system must have internal heat provided if the danger of intake icing is to be reduced. Screens, when used, are usually supplied by the engine manufacturer and create one of the large "ifs" in connection with icing hazards. Performance is seriously affected by intake conditions, so the system should receive considerable attention and analysis in order to provide an optimum design. The benefits and performance loss induced by alternate intakes are being covered by a number of research groups considering the following means to combat icing: (a) increasing inlet air temperature (bleed); (b) heating of hollow inlet guide vanes; (c) inertia separators; (d) electric heating; (e) use of resistant coatings; (f) injection of alcohol at compressor inlet; (g) eddy current heat (magnetization); and (h) retractable inlet screen.

It is felt that icing protection will be obtained by use of any one, or a combination, of the above listed means of combating icing. All of the systems will penalize the aircraft either by performance losses caused by weight increases or by thrust losses and increase of specific fuel consumption. The choice of any particular system is dependent on the thermal and electrical power available and on the allowable performance losses.

Fire Detection and Extinguishing System

A satisfactory fire-detection and -extinguishing system is a "must" on any turbine-powered aircraft used in air-line operation. Although gas turbines have fewer fire hazards than reciprocating engines, because of the elimination of many exhaust connections and more isolation of fuel and lubrication systems from ignition sources, nevertheless, the military record to date shows difficulty from fires due to combustion chamber and rear section failures, contact of fluids with the exhaust, accessory failures, and starting conditions. Fire-wall materials that are substantially vapor and liquid-tight should be provided. Although military, civil, and research agencies have made progress in this direction, it seems that when all the factors are considered it will be necessary that additional design and weight sacrifices be taken to reduce or eliminate fire hazards.

Windmilling

In the event a failure occurs in a reciprocating engine used in air-line operation, it is possible to feather the propeller; such a procedure is not possible with turbojet engines. Accordingly, some means must be developed to control the turbine windmilling problem, since failed turbine engines will revolve as a result of the dynamic pressure of the air at an r.p.m. many times the air speed. In addition to the possible resulting damage to the engine and aircraft structure, with the likelihood of fire occurring, there is also a drag of reasonable magnitude created. There are a number of possible solutions that might be worth consideration to handle this problem, such as (a) front cover, (b) rear cover, and (c) brake mechanism. With the introduction of such power plants in civil aviation, it is necessary that extra precautions be practiced when granting overhaul periods until such time that a background of experience is acquired to use as a yardstick.

Performance

The major problems concerning C.A.A. in *structures*, aircraft *equipment*, and *power plants* have now been briefly covered. It is appropriate we pause here and note that the majority of problems *we expect to develop* are dependent upon, or associated with, a performance action, whether deficient or excessive. Advantages and disadvantages usually go hand in hand, but here, in this section on performance, I find that the few detrimental factors will cause no insurmountable problems.

With the adoption of the turbine engine and its pronounced assets comes an acute sensitivity to atmospheric conditions. I previously discussed one important aspect to this condition—icing. Another important consideration to performance realization follows.

Temperature and Humidity Accountability

To provide a more rational and a more equitable level of safety for the various conditions, we are of the opinion that full temperature accountability should be applied for temperatures above freezing and that, until experience is gained, no credit should be allowed for temperatures below freezing because of the danger of icing. We believe it realistic to propose that average humidity corrections, which admittedly will be small, should be applied with temperature accountability (i.e., a curve of average humidity against temperature should be established, and, therefore, as temperature corrections are made, the appropriate average humidity would be incorporated).

All-Engine Take-Off Path

The take-off field size of present reciprocating-engined aircraft is limited by the one engine-out condition, and

this is considered adequate with temperature accountability, since the day-in-day-out all-engine take-off distance and take-off flight path (at slightly higher speeds than the minimum values used for the engine failure consideration) are still shorter than the engine-failure flight path. With turboprop aircraft the same considerations may govern, although the climb-out speed for day-in-day-out operation on all engines appears to be slightly higher for these aircraft than for those using reciprocating engines. For turbojet aircraft the normal operating climb-out speed is probably considerably higher than that used with reciprocating-engined aircraft, and the all-engine take-off flight path may be more critical in the areas close to the field where the obstacles usually must be avoided by climbing instead of turning. Therefore, it is suggested that the manufacturer schedule in the Airplane Flight Manual an all-engine take-off flight path from the end of the field, with acceleration provided along such a path to a satisfactory climb-out speed and including the gradient of climb with maximum continuous power. This will enable operators to schedule adequate clearance of obstacles and to instruct pilots in the correct normal operation of such aircraft.

Since field size for these aircraft will vary with temperature effects and altitude to a greater degree than with reciprocating-engined aircraft, it is possible that thrust augmentation will be desired for use upon an engine failure on take-off or even in some special cases for use on extremely hot-day all-engine take-offs. Proposals in this regard are still preliminary, and, since little commercial experience has been obtained with operation of these devices and with such aircraft, exact requirements are not known at this time. We believe each case should be handled individually until general requirements can be agreed upon.

Engine Failure Speed

Some concern has been expressed by pilots who have flown turbine-engined aircraft, particularly turbojet aircraft, that an engine may fail early in the take-off run and that, because of the slow acceleration and the close inboard grouping of engines (which reduces the asymmetric thrust effect), they may not realize that an engine has failed for some few seconds. These effects will vary with different types (turbojet; turboprop) and even with different airplanes of the same type. One solution would be the selection of an engine-failure speed at a low value, in which case the accelerate-stop distance would not be critical but only the distance to climb to 50 ft. would limit the field size. It appears that the best solution for the present may be to evaluate each case separately.

Minimum Permissible Take-Off Climb Speeds

The present regulations provide that the minimum take-off climb speed for aircraft of more than two engines, if not limited by the minimum control speed, shall not be less than $1.15V_{s_1}$. For turboprop aircraft this regulation is probably satisfactory, but for turbojet aircraft this would be unsatisfactory, since the permitted speed reduction was intended to provide approximately the same margin of climb-out speed to power-on stall speed for two- and four-engined aircraft. Normally, it would not be practicable to use a minimum take-off climb speed less than the best angle of climb speed (exception is where obstacles beyond the field are not critical), since it is desirable to use the speed that gives the best ability to climb over the obstacles. Therefore, for turbojet aircraft we are inclined to recommend that the minimum take-off speed should remain $1.2V_{s_1}$, regardless of the number of engines and, further, that consideration be given to not permitting it to be less than the best angle of climb speed whether turboprop or turbojet.

Climb

Consideration should be given to the minimum climb performance necessary with these aircraft as affected by variations in climb speed, necessary performance margins, engine-failure rates, deterioration of power between overhaul, etc. In the performance rationalization that is currently being carried on in cooperation with ICAO, the necessary performance margins will be based upon an allowable incident rate. Statistically, since the incident rate is to be maintained as a constant value, a change of engine-failure rate, increased occurrence of multiple failures, or increased variation of variables will require higher performance margins in order not to exceed the allowable incident rate. An example of this is the deterioration of engine power between overhaul periods, which may be higher for turbine engines. If the deterioration of power is higher, a higher performance margin could be specified to assure the same overall level of safety. There is some concern that on turbojet aircraft two or more power plants may be closely grouped in one nacelle. We feel that such installations must be closely examined to assure independence of engine failure.

Since it will be necessary for these aircraft to cruise at high altitude in order to increase their specific air range and also since it will be most desirable to cruise at high speed, compliance with the minimum climb performance requirements at standard temperature will probably be a greatly reduced problem. The take-off, approach, and balked landing climb requirements should be met with large excesses. The en-route requirements may possibly be more critical, particularly the en-route operation requirements.

The present climb requirements appear satisfactory for take-off climb speed considerations, since the take-off climb requirements and take-off path are conducted at the same speed. This is not true with approach and landing climb requirements, since the present regulations permit these requirements to be demonstrated at the best rate of climb speed, which may be considerably higher than the approach speed in demonstration of the landing distance.

To cover the problem of speeds to be used in demonstrating the approach and landing climb, we suggest that the maximum speeds be limited to $1.4V_{s_1}$ and $1.3V_{s_1}$, respectively, unless a higher speed is used in demonstration of the landing distance, in which case such higher speed could be used.

Landing

The problems concerned here are the speeds to be used for approach and landing, the glide angle on approach, the use of reverse thrust where available, and increased reliance upon brakes. We are at present studying this problem and hope to obtain sufficient data to make a complete proposal in the near future.

Turbojet aircraft will not have propellers for reverse thrust, although it appears reasonable to expect that turboprop aircraft will be able to use reverse thrust. We believe that some work is being done on turbojet aircraft on directing the thrust forward by clamshell doors or that other means of assistance in stopping are being developed, but these may still be some time in the future. Therefore, from a performance standpoint, since turbojet aircraft will not have the drag of propellers to assist in stopping, greater brake capacity will probably be needed. In approaches under instrument conditions, it will be necessary to maintain fairly high approach speeds until clear of the instrument weather. Therefore, contact speeds with the runway may be higher than those presently being experienced on reciprocating-engined aircraft; this consideration again suggests greater reliance on brakes.

Until a complete study of landing-field length requirements is completed, we suggest that the minimum speed in demonstration of the landing distance should be that comparable with the speed that would be used in ILS landings at the minimum glide angle of approximately 3° and that this speed should not be less than the speed used in demonstrating the balked landing or approach climb-out unless the applicant can demonstrate ability to attain the desired climb condition at the approach speed with a height loss of not greater than 25 ft. or a distance traversed of not greater than 2,000 ft. from the instant of application of power on the available engines. Careful consideration must also be given to any proposals regarding reverse thrust and minimum brake capacity to assure adequate safety. At the present time we believe these should be considered on an individual basis.

Flight Characteristics

Considering the predicted handling characteristics of a jet transport, there appears to be no great cause for apprehension, although the stability about the rolling and yawing axes may be somewhat jeopardized by low-drag wing geometry and smaller vertical tails. It will therefore be an open challenge to the abilities of our industry to develop methods of improving these characteristics to at least the present level of acceptability.

As discussed in previous sections, many final decisions will not be resolved until operational test programs can determine the level of stability and controllability which can be expected.

Wing Stalling

Two problems are combined in one at the stall. The least significant of the two concerns the inherent stall characteristics of the swept wing. Because of the instability of the wing itself, plus the sequence of loss of lift, a violent and possibly uncontrollable pitch may be anticipated at the stall, accompanied by a serious loss of altitude. Solutions to this portion of the problem lie in the development and judicious application of various auxiliary lift devices, such as extensible leading-edge slats and flaps, suction boundary-layer control, droop nose flaps, fences, etc.

The second problem involves the effect on the airplane structure of prestall and stall buffeting. A buffet that serves merely as an adequate stall warning on present-day aircraft wings may introduce dangerous structural loads on wings of high-speed aircraft because of their built-in flexibility, especially if the aspect ratio is high.

It is well to consider that the C.A.A.'s basic purpose of requiring good stalling characteristics has not changed. If the need for a change in requirements appears, the change should be one of degree rather than intent.

Stability and Control

Aileron effectiveness is materially reduced at low speeds requiring large deflection angles to maintain effective lateral control. Further, tip stall may be expected in basic swept wings of the order above 25° sweepback. As in the previous case, satisfactory stability and control characteristics will be tied in closely with development of auxiliary lift devices. Consideration should be given to requiring positive stability from $1.2V_{s_0}$ to V_{N_E} in all configurations.

Stability at High Altitudes

Control damping decreases generally with increase in altitude. The application of power controls will probably solve the longitudinal case satisfactorily, but various lateral and directional discrepancies may persist until solved by exact control surface design.

It appears most desirable to certificate a jet transport for a specific range of operating altitudes, substantiated by demonstrated satisfactory flight characteristics throughout the certificated altitude range.

Directional and Lateral Stability

Sweepback results in a lower aspect ratio for the same wing area, thus reducing lateral damping. This damping decreases with increase of altitude and decrease of air speed, thus arousing lateral oscillation that induces adverse yaw or "dutch roll."

One suggested method of increasing damping of the lateral oscillation is by the addition of a damping yaw-

ing moment obtained by moving the rudder in proportion to a yawing signal. This signal may take form of the disturbance of a rate gyro unit in the rudder circuit, and the added damping moment will probably be fed in by a rudder servo excited by the same rate gyro.

It is suggested that such an automatic device, if it were dependable, might possibly constitute a satisfactory method of achieving directional and lateral stability. The basic airplane characteristics with the device inoperative should, of course, be safe and controllable.

Operating and Design Speed Range

This is probably the most important flight problem from a standpoint of urgency, because the Civil Air Requirements on this point may significantly govern the basic aircraft design. Unlike reciprocating-engined aircraft, the jet transport would operate most economically and efficiently at a high percentage of its maximum speed—somewhere in the order of 80 to 95 per cent of the maximum speed, depending upon the individual design. The present V_{N_0} concept will probably not be a rational one on the majority of jet transports, since V_{N_0} would be about where V_{N_E} is on reciprocating airplanes and V_D would probably be limited to some degree by handling qualities rather than structural considerations alone. This state of events is due, for the most part, to the extremely high speeds and altitudes achievable by gas-turbine power.

So long as safety of flight could be demonstrated to a degree equivalent to what we have with present reciprocating aircraft, it appears reasonable to reduce the spread between V_{N_E} and V_D to an absolute minimum and to eliminate the specific V_{N_0} by consolidating the intents of V_{N_0} and V_{N_E}. Further study may reveal that such a course of action would permit utilizing the most efficient airplane speeds without compromising safety of flight. Limited experience suggests that possibly a spread of 50 m.p.h. indicated air speed between the speeds associated with the limiting Mach Number and the placard Mach Number might be a safe cushion against adverse compressibility effects. The addition of automatic dive brakes or any other form of braking or warning device might well be treated in the same light as reverse thrust propellers, with no credit given performance-wise but much added safety realized, until such time as more operating experience is gained.

Conclusion

To summarize all the protracted statements that have gone before, we need only say that aircraft structures, in general, must be "beefed-up" to meet the strength requirements of the anticipated higher speeds and extreme operating altitudes.

Power-plant problems will be evident, but these largely will be due to the peculiarities of turboprop and turbojet engines. Much research is needed to overcome several of the most obvious difficulties—i.e., acceleration, icing, blowouts and relighting, and durability. The overall situation is not serious, and a period of adjustment will surely overcome these obstacles.

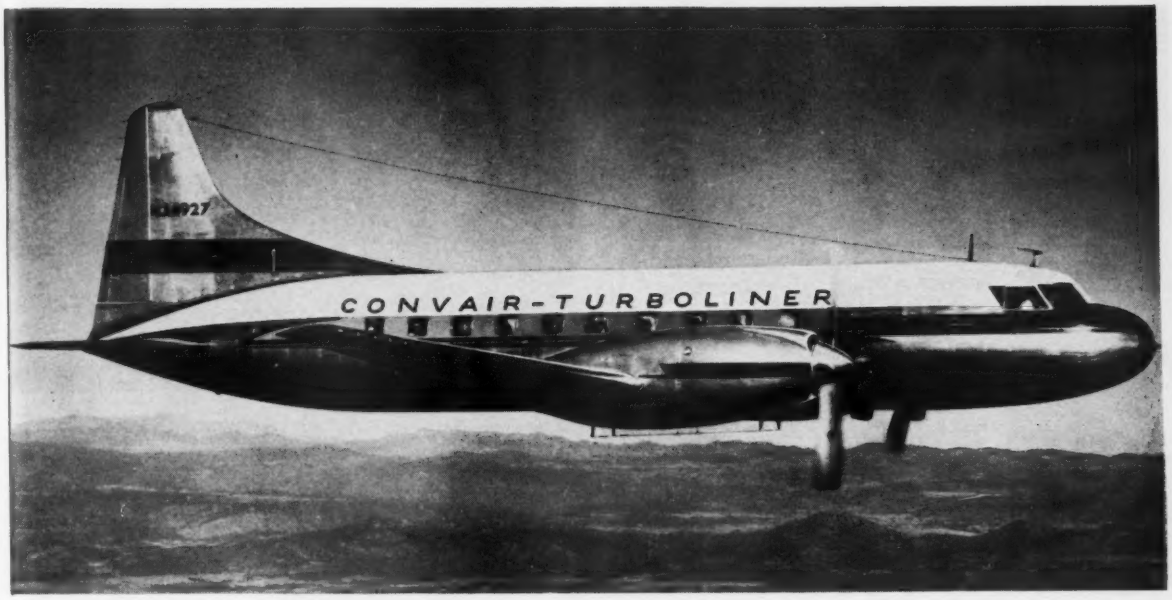
In general, the performance capabilities of the turbine transports will be increased, especially in the climb segments. However, many devices are in advanced stages of development to increase these performance levels and thus to relieve those deficiencies known to exist. Research and operational experience will be necessary to establish proper performance margins to maintain our present level of safety.

In summation, it is already clear that the turbine transport presents many new and, in some respects, more critical performance characteristics than those to which we have become accustomed in the conventional aircraft. Generally speaking, we in the C.A.A. are fully aware that the birth of a new device or innovation in aircraft design or operation is a critical period that must be observed with a certain degree of generosity on the part of regulating groups or the new idea may be restricted out of its fullest and most rapid growth. However, our heavy responsibility for safety of the flying public gives us little leeway in this direction. We are conscious of these dual and, to some degree, mutually exclusive responsibilities and are spending a great deal of time and effort in attempting to foresee the most remote impact of even a minor restriction on these new aircraft. How well we walk this tightrope will be determined not only by the rate of improvement of transport aircraft performance with the advent of the gas turbine engine but by the increase in safety of the flying public as well. If we can accomplish both these ends simultaneously, then the manufacturers, the air lines, the C.A.B., and the C.A.A. jointly will have achieved a significant goal.

Changes of Address

Since the Post Office Department does not as a rule forward magazines to forwarding addresses, it is important that the Institute be notified of changes in address 30 days in advance of publishing date to ensure receipt of every issue of the *Journal* and *Review*.

Notices should be sent directly to the Institute of the Aeronautical Sciences, Inc., 2 East 64th Street, New York 21, N.Y.



Current Turboprop Power-Plant Installations

F. H. SHARP*

Consolidated Vultee Aircraft Corporation

TURBOPROP INSTALLATIONS IN AIRPLANES in this country can be classified into three groups—past, present, and near future.

The past aircraft (by "past" is meant that only one of a type was constructed and is considered obsolescent) include the Consolidated Vultee XP-81 and the Ryan XF-2R-1 Dark Shark. The present aircraft (airplanes on flight status) are the Consolidated Vultee XP5Y-1 and the Douglas XA-2D. The future aircraft (turboprop installations that have not yet flown) include military projects and the Consolidated Vultee Turboliner, a modified 240 with the Allison XT-38 turboprop. Not included in the above groups were the engine manufacturers' test B-17 airplanes, one with a T-38 and one with a T-35 turbine installed in the nose. These were strictly flying test stands, since the four reciprocating engines were still the prime motivating power.

This paper will be concerned with Convair's contributions to the turboprop field, inasmuch as these applica-

Presented at the Session on Propulsive Systems, Annual Summer Meeting, I.A.S., Los Angeles, July 12–14, 1950.

* Assistant Project Engineer, San Diego Division.

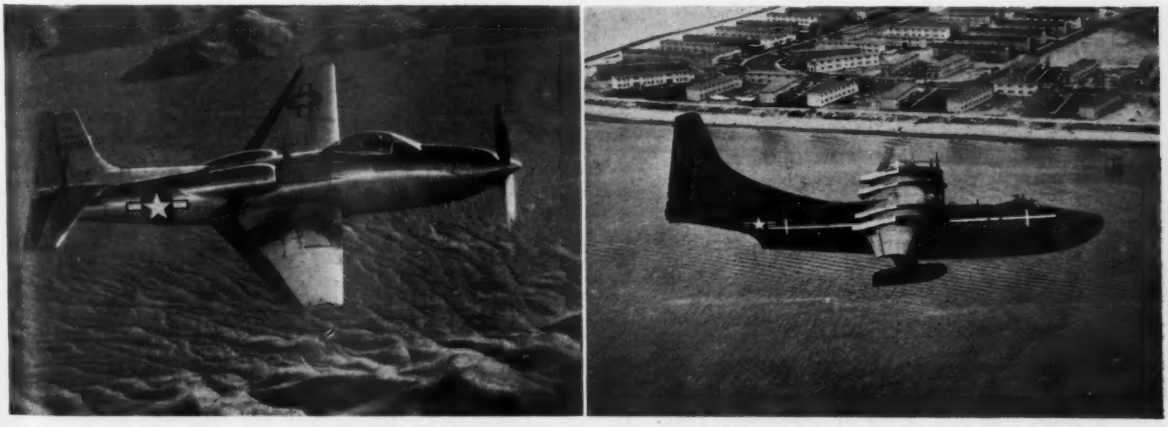


FIG. 1. *Left:* XP-81 in flight. *Right:* XP5Y-1 in flight.

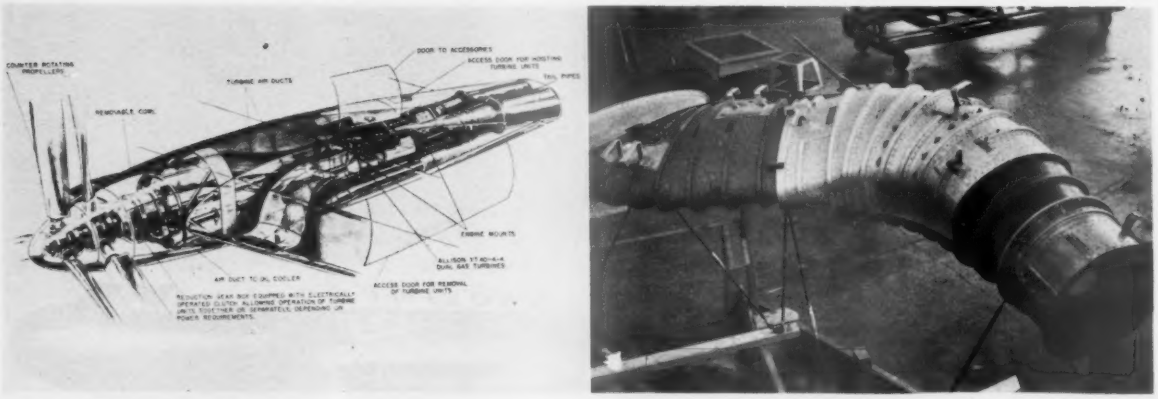

COUNTER ROTATING PROPELLERS
TURBINE AIR DUCTS
DOOR TO ACCESSORIES
ACCESS DOOR FOR HOISTING TURBINE UNITS
REMOVABLE CORE
ENGINE MOUNTS
ALLISON XT-40-4-4 DUAL GAS TURBINES
AIR DUCT TO OIL COOLER
ACCESS DOOR FOR REMOVAL OF TURBINE UNITS

FIG. 2. *Left:* XP5Y-1, complete power-plant installation. *Right:* XP5Y-1, air intake duct.

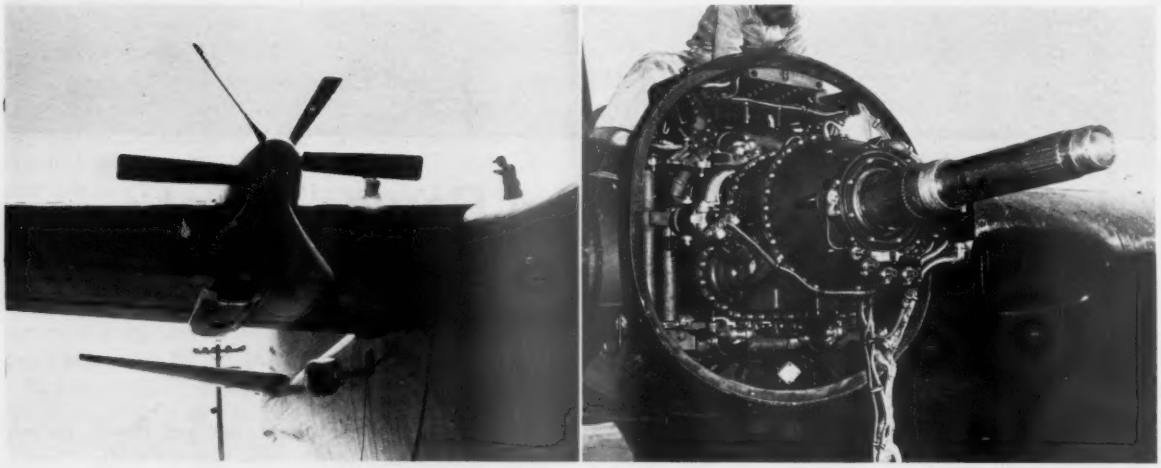


FIG. 3. *Left:* XP5Y-1, nacelle showing duct inlets. *Right:* XP5Y-1, gearbox installation.

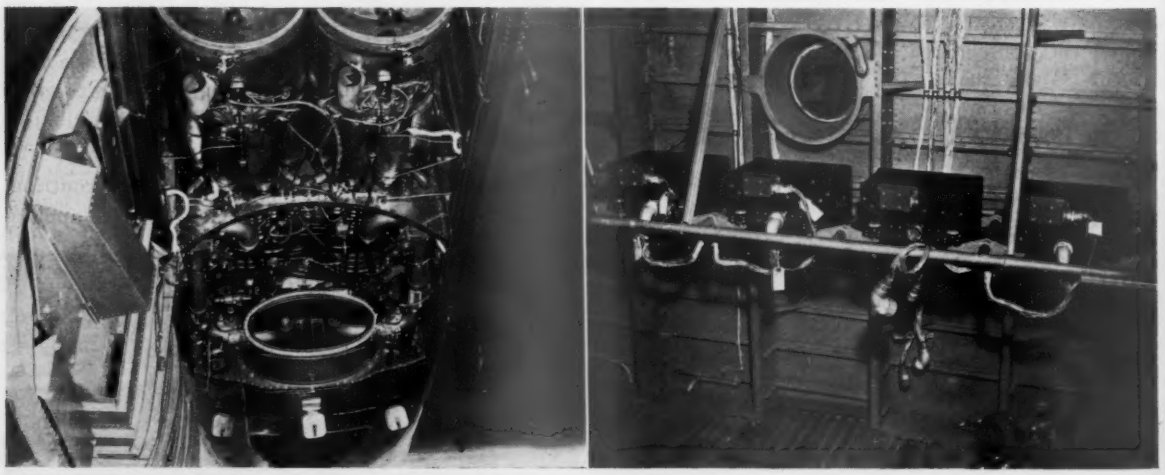


FIG. 4. *Left:* XP5Y-1, oil cooler augmentors. *Right:* XP5Y-1, propeller governors.

tions cover a rather general scope—i.e., fighter, patrol bomber, and commercial aircraft.

The first turboprop installation in this country was in the XP-81 airplane, a single-place escort fighter. This airplane was first flown in December, 1945. It was powered by a General Electric TG-100 turboprop in the nose and a General Electric I-40 turbojet in the tail. During the course of flight testing and working the bugs out of the propeller-turbine control system, the TG-100 project was discontinued.

The XP5Y-1 flying boat was originally designed for four Westinghouse model 25D turboprop engines.

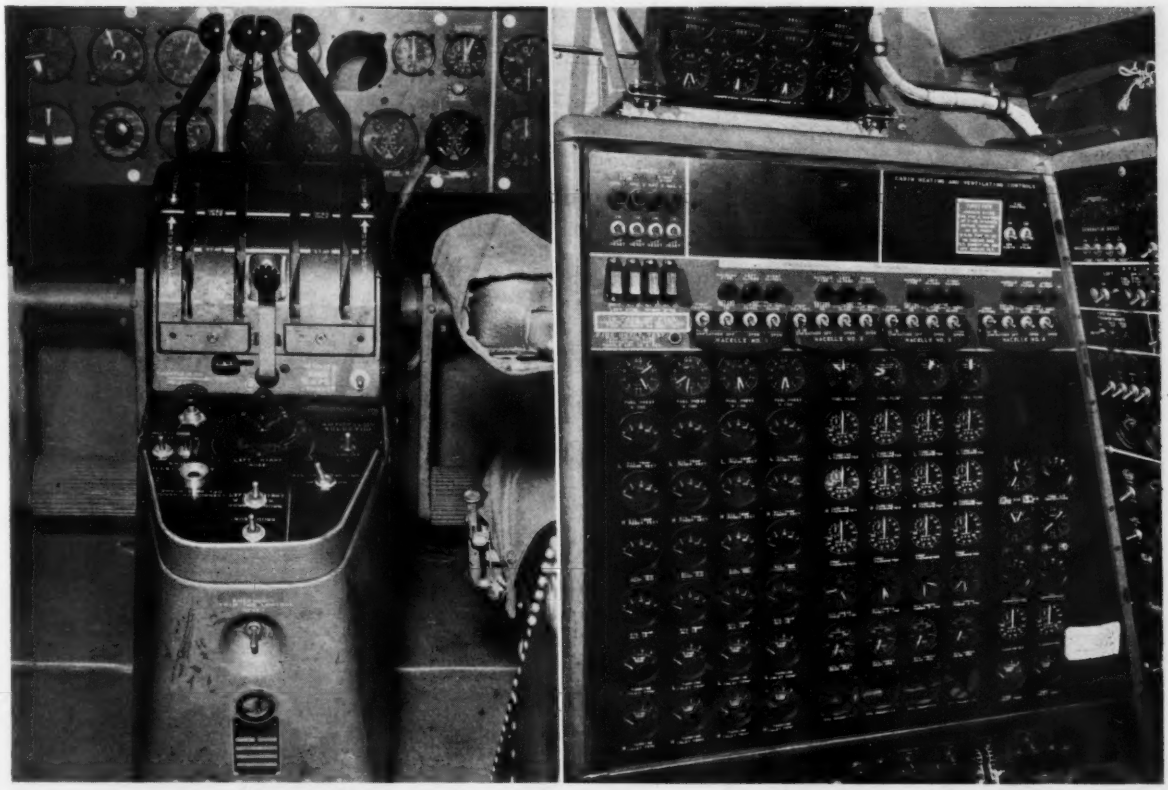


FIG. 5. *Left:* XP5Y-1, pilot's throttles. *Right:* XP5Y-1, flight engineer's instrument panel.

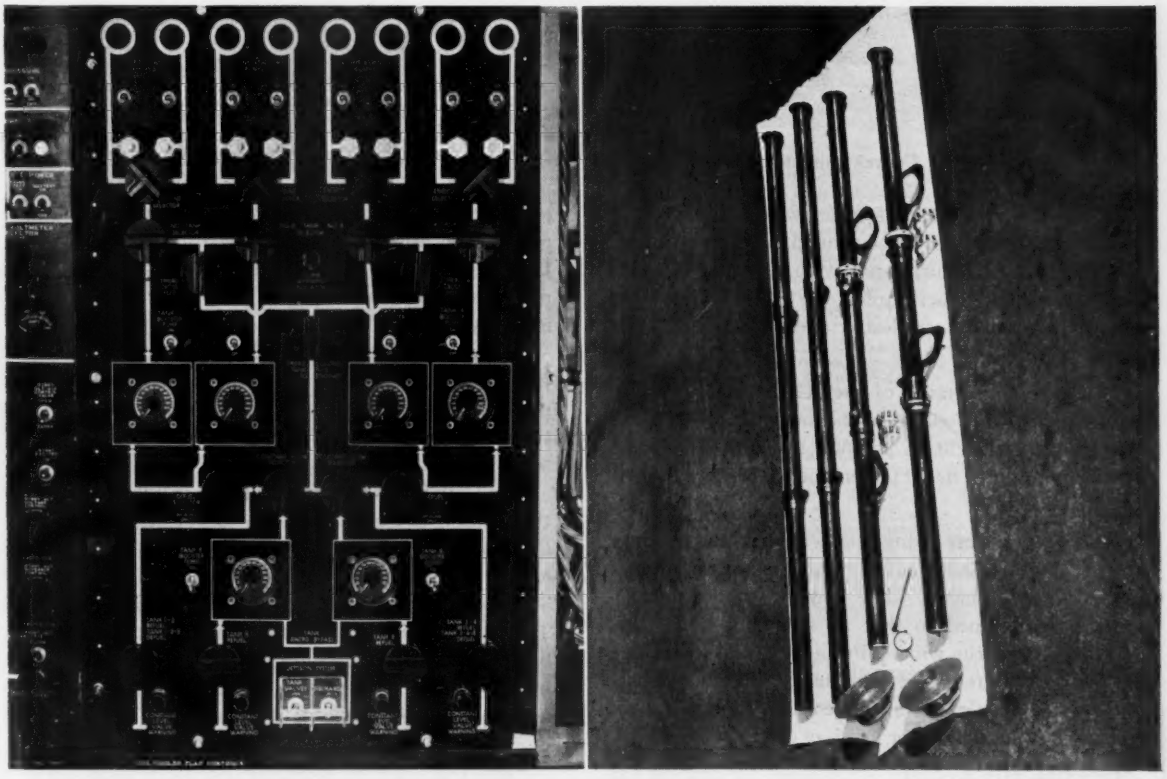


FIG. 6. *Left:* XP5Y-1, fuel control panel. *Right:* XP5Y-1, alignment shafts.

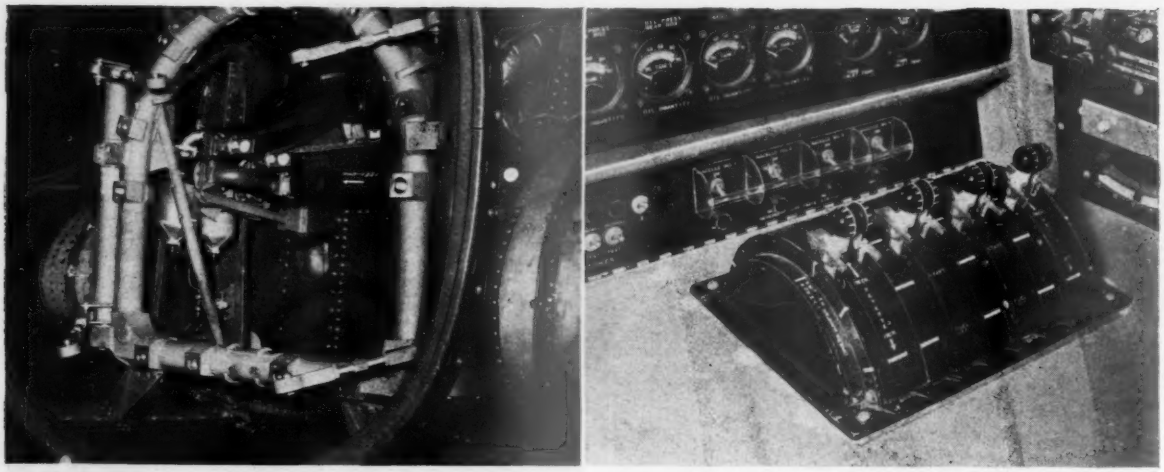


FIG. 7. *Left:* XP5Y-1, gearbox mount. *Right:* XP5Y-1, flight engineer's throttles.

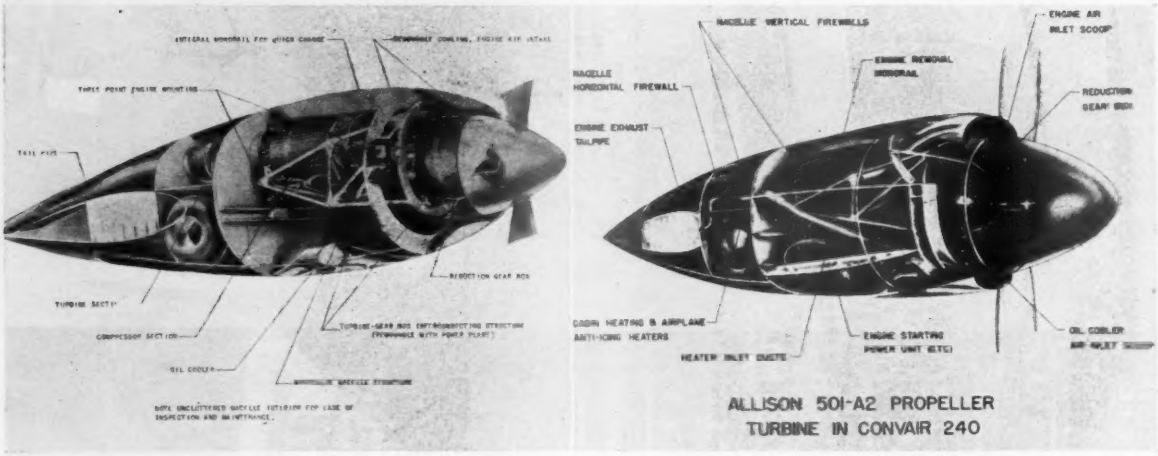

NACELLE VERTICAL FIREWALLS
ENGINE AIR INLET SCOOP
NACELLE HORIZONTAL FIREWALL
ENGINE EXHAUST TAILPIPE
REDUCTION GEAR BOX
CABIN HEATING & AIRPLANE ANTI-ICING HEATERS
ENGINE STARTING POWER UNIT (ETC)
OIL COOLER AIR INLET SCOOP
ALLISON 501-A2 PROPELLER TURBINE IN CONVAIR 240

FIG. 8. Convair Turboliner XT-38 installation. *Left:* Plennum intake. *Right:* Scoop intake.

Spars and bulkheads had been assembled in the wing buck when work was discontinued on this turbine. The Allison XT-40 turboprop with long drive shafts was then selected to accomplish the change to another engine with minimum redesign and rebuilding of the airplane.

The flight performance of the XP5Y-1 airplane can best be pictured by looking at its power loading. With a design gross weight of 123,500 lbs. and equivalent shaft horsepower of 5,500 per engine, the power loading is 5.6 lbs. per hp.

The design of this flying boat calls for the airplane to be self-sufficient in advance areas and to operate from unprepared bases. The power-plant installation is therefore designed so that all servicing can be accomplished from the wing. Propellers, gearboxes, and turbines can be removed and installed with hoisting equipment carried in the airplane and a boat below the wing while riding at anchor in a bay or lagoon.

Maximum ram recovery is obtained by placing the air intake ducts in the wing leading edge behind the pressure peak of the propeller. Minimum frontal area results from the submerged installation of the turbines. Locating the wing rear spar at the 40 per cent chord provides sufficient trailing-edge space for this type of installation.

One power-control lever per nacelle is provided for the pilot. The flight engineer, however, has eight power control levers and full turbine instrumentation to give him individual control over all eight power sections.

The Convair Turboliner is a 240 air liner powered by the Allison XT-38 turboprop and is being built for General Motors Corporation. Each of the two nacelles carries a single power section coupled to its gearbox by an interconnecting structure and short drive shaft. The assembly is then mounted in the nacelle structure by a three-point suspension system. An interesting increase in performance of the airplane is anticipated as compared with the R-2800-powered 240 airplanes now flying.

Figs. 1–8 serve to illustrate the three airplanes discussed.

I.A.S. Preprints

Preprints of I.A.S. Meeting Papers Currently Available

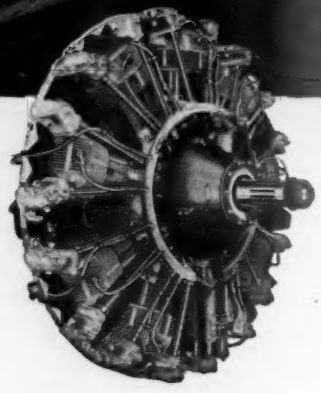
(All produced in accordance with new format except those marked with an asterisk)*

		Member Price	Nonmember Price
305	Dynamic Analysis of Aeroelastic Aircraft by Transfer Function-Fourier Methods—James B. Rea.	$0.35	$0.75
304	Aeroelastic Problems in a High-Speed Bomber—E. S. Hodder.	0.35	0.75
303	Some Roll Characteristics of Cruciform Delta Wings at Supersonic Speeds—Z. O. Bleviss.	0.35	0.75
298	Operating Problems of Turbine-Powered Aircraft—R. D. Kelly.	0.35	0.75
297	The Application of Pressure Refueling to Flight—G. E. Woods-Humphery.	0.35	0.75
296	Supersonic Wing-Body Lift—George Morikawa.	0.50	0.75
295	Current Turboprop Power-Plant Installations—F. H. Sharp.	0.35	0.75
294	Progress in Stall Research—Graham Campbell and Gifford Bull.	0.50	0.75
293	A Method of Presenting the Performance of Turbojet Engines—C. A. Meyer and H. L. Faught.	0.35	0.75
292	A Superposition Method for Calculating the Aeroelastic Behavior of Swept Wings—R. B. Brown, K. F. Holtby, and H. C. Martin.	0.50	0.75
291	Civil Air Regulations for Turbine-Powered Aircraft—George W. Haldeman.	0.35	0.75
289	The Minimum Drag of Thin Airfoils in Frictionless Flow—R. T. Jones.	0.35	0.75
288	Lateral Control of Personal Aircraft at High Lift Coefficients—Francis M. Rogallo.	0.35	0.75
287	Some Factors Affecting Large Transport Aeroplanes with Turboprop Engines (Wright Brothers Lecture)—A. E. Russell.	0.50	1.00
281	Turbine-Powered Transport Development—R. D. Kelly and Frank Davis.	0.35	0.75
280	Propulsion Analysis for Long-Range Transport Airplanes—A. Kartveli.	0.35	0.75
279	Optimum Performance of Rocket-Powered Missiles—Allen E. Puckett.	0.35	0.75
277*	Do We Need Turboprops?—E. V. Farrar and R. E. Johnson.	0.35	0.75
275*	Fire Out—by Design—H. L. Hansberry.	0.35	0.75
274*	Maintenance of Safety Attitudes in Air Transport Operation—Robert Knight.	0.35	0.75
267	Acoustic Measurement of Airstream Parameters—Victor B. Corey.	0.35	0.75
265	Progress in Fire Prevention—Following Crash—Lewis A. Rodert.	0.35	0.75
264	A Recurrence-Matrix Solution for the Dynamic Response of Elastic Aircraft—John C. Houbolt.	0.50	0.75
263	A Mechanical Analogy for Hypersonic Flow—H. Reese Ivey.	0.35	0.75
262	Design and Operational Features of the Sikorsky 1,000-Hp. Helicopter Rotor Test Stand—Harry Jensen.	0.35	0.75
261	Kinematic Behavior of the Human Body During Crash Deceleration—E. R. Dye.	0.35	0.75
259	Analysis of the Elastic and Plastic Stability of Sandwich Plates by the Method of Split Rigidities—P. P. Bijlaard.	$0.65	$1.00
258	Types of Inelasticity of Structural Materials and Procedures of Design—Alfred M. Freudenthal.	0.50	0.75
257	An Initial Approach to the Overall Structural Problems of Swept Wings Under Static Loads—E. F. Sechler, M. L. Williams, and Y. C. Fung.	0.35	0.75
255	The Gyroscopic Effect of a Rigid Rotating Propeller on Engine and Wing Vibration Modes—R. H. Scanlan and John C. Truman.	0.50	0.75
254	The Solution of Aeroelastic Problems by Electronic Analogue Computation—Jonathan Winson.	0.50	0.75
253	A System for the Excitation of Pure Natural Modes of Complex Structure—Robert C. Lewis and Donald L. Wrisley.	0.65	1.00
252	A Method of Determining Some Aerodynamic Coefficients from Supersonic Free-Flight Tests of a Rolling Missile—R. E. Bolz and John D. Nicolaides.	0.65	1.00
251	The Longitudinal Stability of Elastic Swept Wings at Supersonic Speed—Charles W. Frick.	0.50	0.75
250	The Rolling-Up of the Trailing Vortex Sheet and Its Effect on the Downwash Behind Lifting Wings—John R. Spreiter and Alvin H. Sacks.	0.65	1.00
249	On the Stability of Two-Dimensional Transonic Flows—Y. H. Kuo.	0.35	0.75
248	The Transient Temperature Distribution in a Wing Flying at Supersonic Speeds—Joseph Kaye.	0.65	1.00
247	Lift on Inclined Bodies of Revolution in Hypersonic Flow—G. Grimminger, E. P. Williams, and G. B. W. Young.	0.65	1.00
246	A Precision Omnidirectional Radio Range for the Terminal Area—Joseph Lyman and George Litchford.	0.35	0.75
245	A Type of Lifting Rotor with Inherent Stability—Kurt H. Hohenemser.	0.50	0.75
242*	The Calculation of Supersonic Downwash, Using Line Vortex Theory—Harold Mirels and Rudolf Haefeli.	0.35	0.75
237*	Predictions of Supersonic Airplane Performance—Harold Luskin.	0.35	0.75
236*	Analysis and Design of Stiffened Shear Webs—Paul H. Denke.	0.35	0.75
235*	A Summary of Flight Load Data Recorded in Tactical and Training Operations During the Period of World War II—Lawrence B. Reynolds.	0.35	0.75
234*	Theoretical Lateral-Stability Derivatives for Wings at Supersonic Speeds—Arthur L. Jones.	0.35	0.75
233*	Some Operational Aspects of Distance-Measuring Equipment in the Transitional Air Navigation System—J. Wesley Leas.	0.35	0.75
232*	The Development of a Course Line Computer for the Air Navigation System—Chester Watts and Francis Gross.	0.35	0.75

Preprints should be ordered by number from:

Preprint Department, Institute of the Aeronautical Sciences

2 East 64th St., New York 21, N.Y.



***POWER PLANT FOR THE FREIGHTER** — Two Wright Cyclone 9's... rated at 1475 hp. . . . provide the Chase Avitruc with high power for short take-offs . . . low weight for increased payload . . . durability for greater utilization.*

Freighter.. OR

The versatile family of service-proved Wright Cyclone engines powers each of these widely different aircraft with an engine ideally suited to its needs.

▶ **The Chase C-122 Avitruc**—Air Force assault transport—takes off from and lands on short unimproved fields, must load and unload fast, and deliver troops and equipment in effective numbers.

▶ **The Douglas AD Skyraider**—new Navy "Airborne Arsenal"—flies up to 10,000 lbs. of bombs and rockets at 500 miles an hour; is versatile, rugged, famous for long-range capabilities.

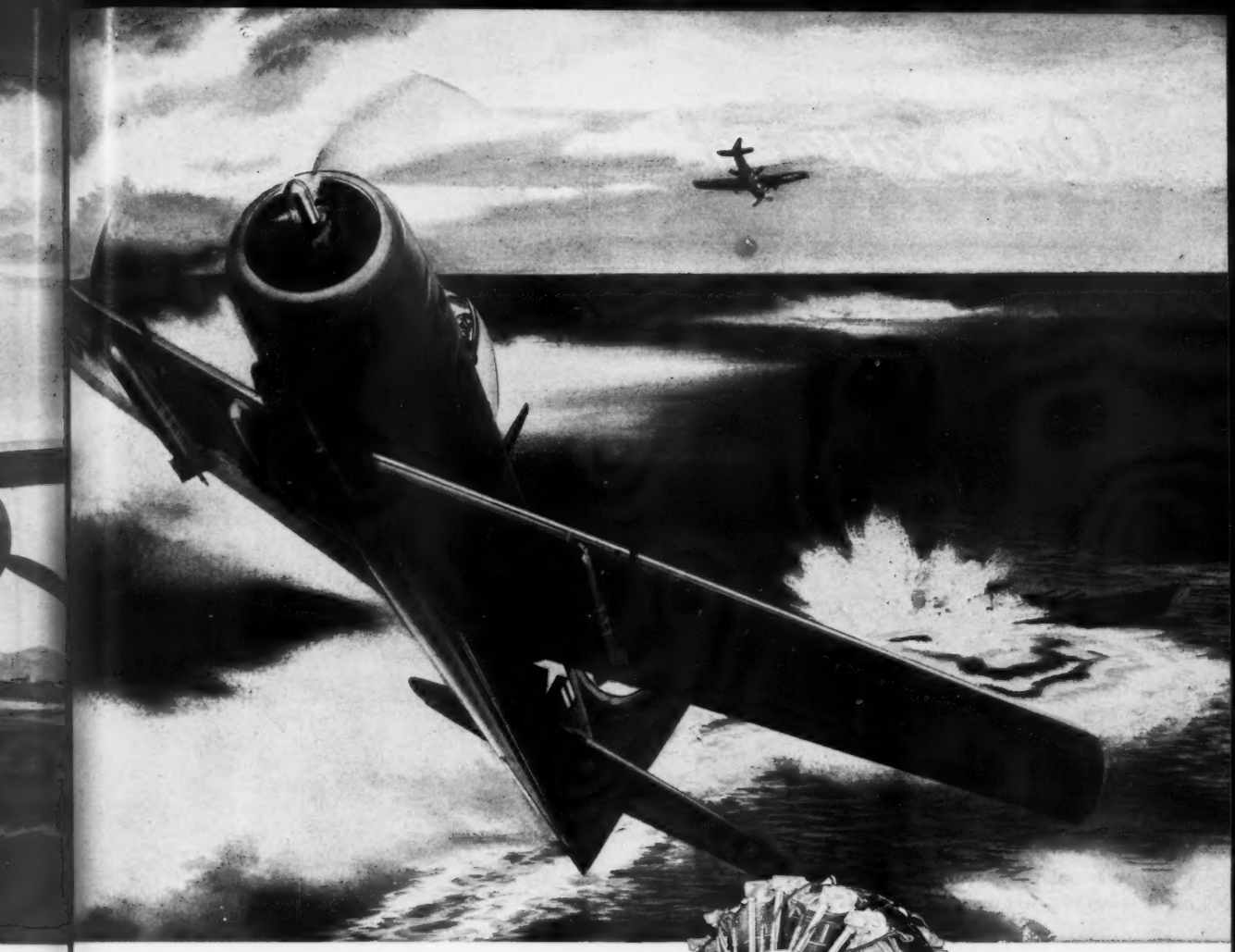
▶ The
Each
power
engine

W

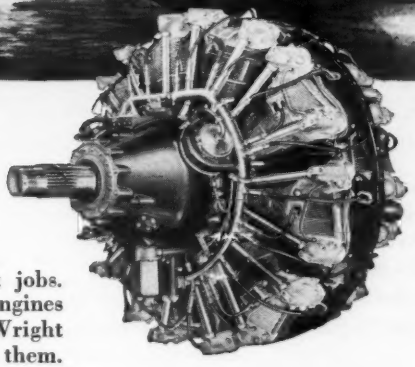
Lockheed P2V-4 Neptune

Piasecki H-21 Rescuer

Martin P5M Marlin



..OR Fighter

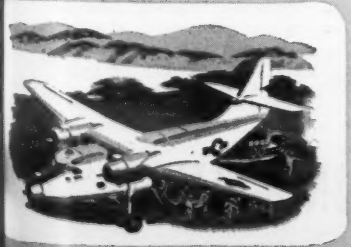


***POWER PLANT FOR THE FIGHTER** — For the Douglas attack bomber, a single Wright Cyclone 18 delivers 2700 hp. for take-off . . . is designed and built to provide exceptional take-off, climb and range performance for carrier aircraft.*

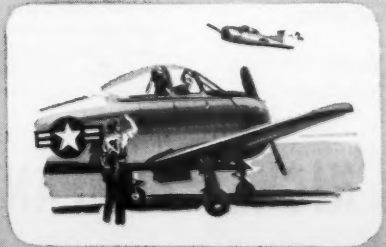
▸ The six aircraft shown below do other important jobs. Each has its own special power needs—and Wright engines power them all. The future will bring new needs, and Wright engineering and production teams are ready to handle them.

WRIGHT Aeronautical Corporation, Wood-Ridge, N. J.
A DIVISION OF CURTISS-WRIGHT CORPORATION

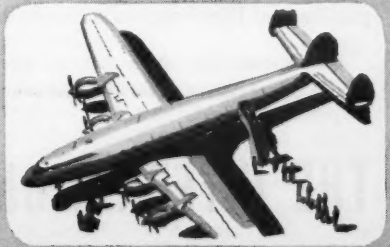
Northrop C125 Raider



North American T-28 Trainer

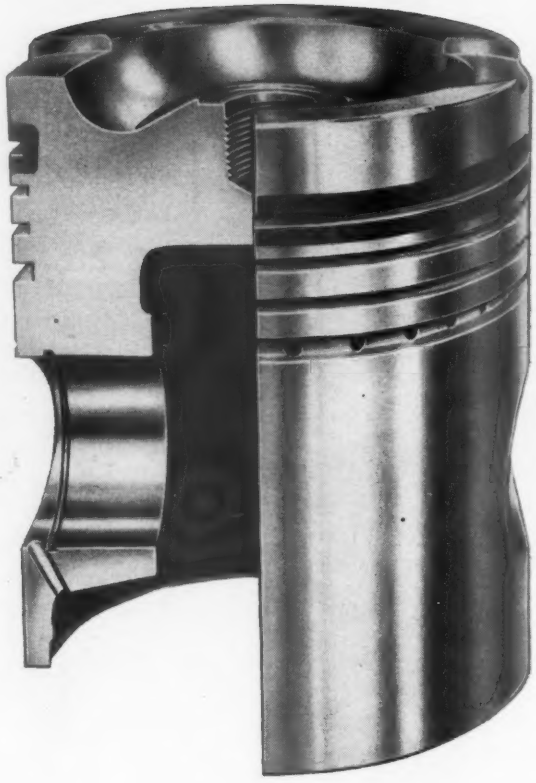


Lockheed Constellation



One Secret of

INCREASED POWER
LOWER MAINTENANCE
LONGER ENGINE LIFE



A NI-RESIST INSERT . . . bonded into aluminum alloy piston by the Al-Fin process.

Standard aluminum alloy piston which failed in the top ring groove.

ELIMINATE excessive failures from wear, burning and erosion in the ring area of aluminum alloy pistons . . .

Particularly in the top ring groove . . . which encounters the most heat, receives the least lubrication, and faces wear from abrasive dust and dirt coming in through the intake.

A NI-RESIST® band gives the stop-sign to excessive ring groove wear and, thus, curbs unnecessary oil consumption and needless loss of power due to "blow-by."

Records show that these troubles end when the Al-Fin process for molecular bonding of aluminum to iron or steel is used to make Ni-Resist ring carrier bands an integral part of pistons.

Ni-Resist . . . a high nickel alloy cast iron . . . meets all demands for this application. It resists heat, corrosion, metal-to-metal wear and galling. Moreover, its high thermal expansion coefficient is close to that of aluminum alloy 142 and 132 ("Lo-Ex") to which it is bonded by the Al-Fin process . . . developed by Al-Fin Division of Fairchild Engine and Airplane Corporation, Farmingdale, L. I.

Rings operating in Ni-Resist bands are unable to chew their way into the ring bands, and service records show remarkable improvement in piston life, as well as higher power per cylinder.

United Engine & Machine Company of San Leandro, California, is one of several concerns in this country and abroad, licensed to manufacture bimetal products by the Al-Fin process. United's "Dualoy" bonded aluminum Ni-Resist pistons are now marketed as original equipment and replacements for both gasoline and Diesel engines in trucks, buses and tractors.

We welcome the opportunity to give you counsel and data on the use of Ni-Resist for this and other uses in industry.

EMBLEM OF INCO SERVICE

Over the years, International Nickel has accumulated a fund of useful information on the properties, treatment, fabrication and performance of engineering alloy steels, stainless steels, cast irons, brasses, bronzes, nickel silver, cupro-nickel and other alloys containing nickel. This information is yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 WALL STREET
NEW YORK 5, N. Y.

I.A.S. Previews

Summaries of Current Papers Accepted for I.A.S. Publications

On the Stability of Two-Dimensional Smooth Transonic Flows

By

Yung-Huai Kuo
Cornell University

Steady two-dimensional potential flows involving imbedded supercritical regions adjacent to a body have been calculated, but their existence has not yet been established experimentally. To further experimentation, the question of stability of such flows is examined.

Following the standard procedure, a theoretically possible flow is disturbed at a certain instant, and the behavior of the subsequent disturbance motion is investigated. By means of the transonic approximations, a simple solution valid in the neighborhood of the sonic line has been obtained. This study leads to the conclusion that (1) smooth decelerating transonic flows over bodies at negative curvature are unstable to compression pulses; (2) smooth accelerating transonic flows over any surface are stable; and (3) smooth transonic flows with local supersonic region are unstable.

Preprint No. 249

The Rolling Up of the Trailing Vortex Sheet and Its Effect on the Downwash Behind Wings

By

John R. Spreiter and Alvin H. Sacks
Ames Aeronautical Laboratory, N.A.C.A.

The motion of the trailing vortices associated with a lifting wing is investigated by theoretical and visual-flow methods for the purpose of determining the proper vortex distribution to be used for downwash calculations. Both subsonic and supersonic speeds are considered in the analysis.

It is found that the degree to which the vortices are rolled up depends upon the distance behind the wing and upon the lift coefficient, span loading, and aspect ratio of the wing. While the rolling up of the trailing vortices associated with high-aspect-ratio wings is of little practical importance, it is shown that, with low-aspect-ratio wings, the trailing vortex sheet may become essentially rolled up into two trailing vortex cores within a chord length of the trailing edge.

The downwash fields associated with the two limiting cases of the flat vortex sheet and the fully rolled-up vortices are investigated in detail for both subsonic and supersonic speeds. The intermediate case in which the rolling-up process is only partially completed at the tail position is also discussed.

Preprint No. 250

Wind-Tunnel Tests for Temperature Recovery Factors at Supersonic Velocities

By

W. F. Hilton
The Johns Hopkins University

Temperatures were measured on the surface of a tangential ogive attached to a 4-in. diameter cylinder. The tests were made at Mach Numbers of 1.73 and 2.00 in the Ordnance Aerophysics Laboratory wind tunnel in Texas. The model was made of Lucite, a thermal insulator, and the tests showed that the surface temperature experienced 88.0 per cent of the adiabatic stagnation temperature rise of the airflow just clear of the boundary layer. The experimental scatter amounted to about $\frac{1}{2}$ per cent. These results compare with Squire's theory, which gives 89.42 per cent for a turbulent, and 84.56 per cent for a laminar, boundary layer.

The observed temperatures gave no indication of the position of transition, which is thus at variance with the work of Hilton and Wingham at high subsonic speeds.

Turbulent Boundary Layer in Compressible Fluids

By

E. R. Van Driest
North American Aviation, Inc.

The continuity, momentum, and energy differential equations for turbulent flow of a compressible fluid are derived, and the apparent turbulent stresses and dissipation function are identified. A general formula for a skin friction including heat transfer to a flat plate is developed for a thin, turbulent boundary layer in compressible fluids with zero pressure gradient. Curves are presented giving skin-friction coefficients and heat-transfer coefficients for air for various wall-to-free-stream temperature ratios and free-stream Mach Numbers.

In the special case when the boundary layer is insulated, this general formula yields skin-friction coefficients higher than those given by the von Kármán wall-property compressible-fluid formula but lower than those given by the von Kármán incompressible-fluid formula. Heat transfer from the boundary layer to the plate generally increases the friction and heat-transfer coefficients.

Please do not order Preprints of these papers at this time.
See page 45 for Preprints that are immediately available.

Remarks on Low-Aspect-Ratio Configurations in Supersonic Flow

By

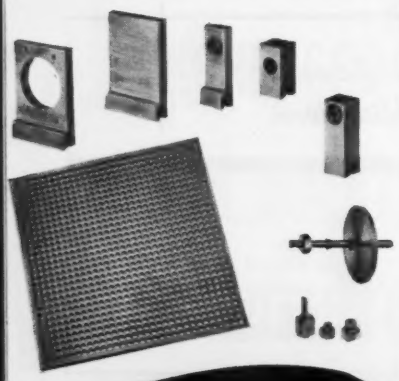
P. A. Lagerstrom and M. E. Graham
Douglas Aircraft Company, Inc.

Simple low-aspect-ratio configurations are examined to obtain a qualitative understanding of wing-fuselage interference and "afterbody" effect of a missile. Slender-body theory gives for a wing-body combination a value of lift which does not depend upon afterbody length. This value of lift is compared with that given by the more exact linearized three-dimensional theory. Nonlinear and viscous effects are not considered.

A theorem is proved concerning the lift of certain wings (or wing-fuselage combinations) with a long afterbody of span equal to the maximum span of the wing. It states that at any supersonic Mach Number the value of lift according to linear theory tends to that predicted by

PACKAGED
Functional Electronics

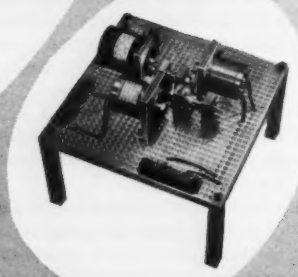
mecha
development apparatus



Servomechanisms, Inc., **Mechanical Development Apparatus** provides the designer with an extensive selection of precision components for rapid and economical assembly of gear trains and actuator devices. Typical applications are analog computers, signal generators, process programmers.

- Foundation Boards
- Bearing Blocks
- Mounting Brackets
- Gears and Shafts
- Miscellaneous Accessories

Write for Descriptive literature



SERVOmechanisms inc.

Old Country & Glen Cove Roads
MINEOLA, N. Y.
Garden City 7-0754-5-6

slender-body theory as the length of the afterbody tends to infinity. The effect of a finite afterbody can also be determined by linear theory, and a comparison can be made with slender-body theory for certain planar systems.

These results may be applied qualitatively to wing-body combinations. They indicate that, for no afterbody, slender-body theory overestimates the lift of the combination and, for a short afterbody, it may equal or even underestimate the lift. For an infinitely long afterbody it agrees exactly with linear theory if the afterbody span equals the maximum wing span; if the afterbody is narrower, it overestimates the lift.

Design and Performance of a Simple Interferometer for Wind-Tunnel Measurements

By

Harry I. Ashkenas and Arthur E. Bryson

California Institute of Technology

The design of an interferometer with a $3^1/_2$-in. diameter light field and its application to a continuously operating 4- by 10-in. supersonic wind tunnel are discussed. The main features of this interferometer are (1) its extremely low cost compared to previous designs; (2) its light weight and flexibility; (3) its simplicity, permitting the instrument to be used also as a schlieren system; and (4) its unique feature of passing both light beams through the test section to minimize the effect of the sidewall boundary layers in the interferograms.

On the One-Dimensional Theory of Flame Structure

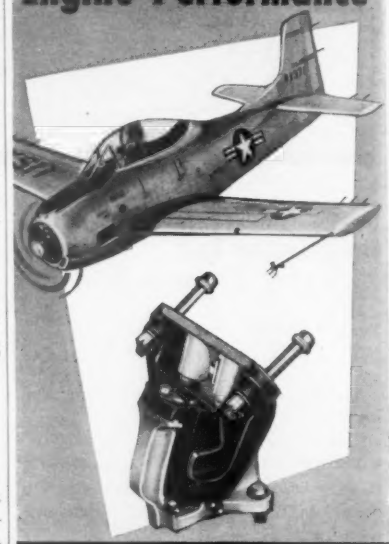
By

Raymond Friedman and Edward Burke

Westinghouse Electric Corporation

The dependence of the temperature distribution in a premixed gas flame on burning velocity, flame thickness, heat-release pattern, and the physical properties of the mixture is calculated from the fundamental equations. By an analogous procedure, the local concentration of a chemical species created in the flame is obtained; both distributions are shown to be of the same form. The general equations are solved for a variety of heat-release patterns (or species formation patterns), and numerical values are presented over a wide range of parameters, so that the influence of the pattern on the distributions may be seen. Solutions are obtained both under the assumption of constant transport coefficients—i.e., thermal conductivity and diffusion coefficient—and under the assumption that these coefficients vary with temperature. The results, which are presented in tabular and graphical form,

Smooth
Engine Performance



North American T-28's
USE LORD
DYNAFOCAL MOUNTINGS

North American Aviation's T-28 Advanced Trainer is used to train pilots for ultra-high speed jet aircraft. The smoothness which the LORD MR-27 Dynafocal gives to the Wright R-1300 engine accustoms these pilots to the smoothness of the jet-powered planes they will fly later.

LORD designed many new and improved features into the MR-27 Dynafocal to make it more efficient and more economical. Lower natural frequencies increase vibration-isolating efficiency to as much as 95% . . . fewer basic parts make installation and maintenance easier . . . new flexing element has greater oil resistance . . . and a selective-action damper reduces excessive engine motion.

LORD engineers specialize in methods for controlling vibration in aircraft and all other types of mechanical products. They can make your product more desirable . . . more salable . . . by giving it smoother, quieter operation. Submit details of your problems to Product and Sales Engineering Department.

LORD MANUFACTURING COMPANY
ERIE, PENNSYLVANIA

Canadian Representative:
Railway & Power Engineering Corporation, Ltd.

LORD
BONDED RUBBER

Vibration-Control Mountings
. . . Bonded-Rubber Parts

may be used directly to relate experimental information of reaction-zone thickness, burning velocity, species concentrations, and temperatures in the flame zone. The flame measurements of Wolfhard are discussed in relation to the equations developed in this paper.

Purely Rolling Oscillations of a Rectangular Wing in Supersonic Flow

By
Ting-Yi Li
California Institute of Technology

The purpose of this note is to show a method of solution of the purely rolling oscillations of a rectangular wing in supersonic flow and to present some numerical results. From these results it is possible to construct vector diagrams of the rolling moments acting on wings of several aspect ratios (A.R. $= 1/\beta$, 1, 3, 5, ∞) at two Mach Numbers ($M = 10/7$, 2) for a range of reduced frequencies ($0 \leqslant k_c \leqslant 2.0$). Thence, it is found that the tips of a finite wing tend to produce two effects: namely, (1) to reduce the real part of the rolling moment vectors and (2) to shift the rolling moment vectors in the positive direction. It is believed that these effects are of great importance for estimations of the damping in roll.

Transonic Flow Past Wedge Sections

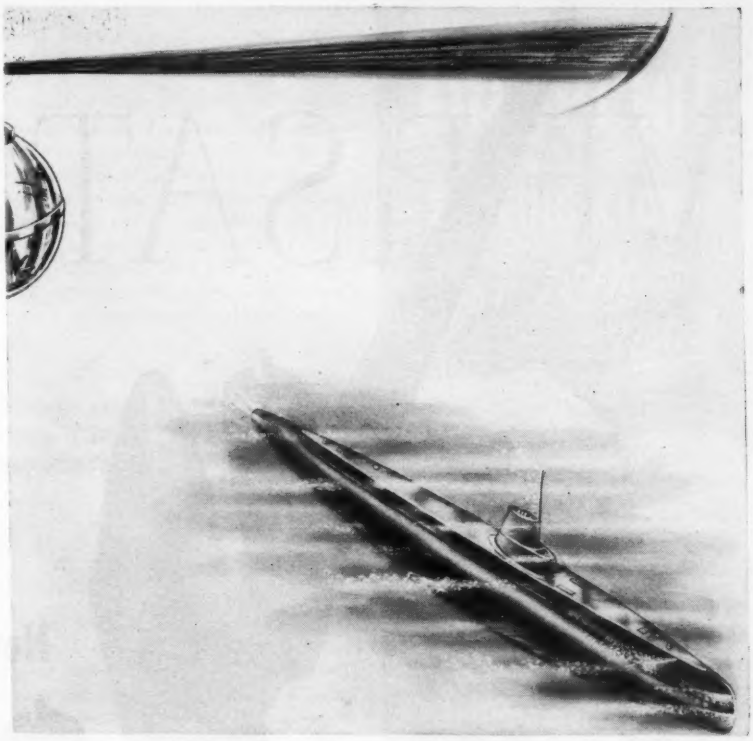
By
H. W. Liepmann and A. E. Bryson, Jr.
California Institute of Technology

The paper gives the results of an interferometric wind-tunnel study of transonic flow past wedge sections. Both subsonic flow with a local supersonic zone and supersonic flow with a detached shock wave have been investigated. The pressure distribution on these wedges and the drag coefficients as functions of the Mach Number have been obtained. The results are compared with general theoretical considerations and recent theoretical work of Guderley and especially of Vincenti and of Cole. Based on theory and experiment, the behavior of the drag curve from $M = 0$ through $M = 1$ to supersonic flow can be completely determined.

Free and Forced Vibrations of Rotating Blades

By
Robert Plunkett
The Rice Institute

The matrix equations governing transverse vibration of a rotating, twisted, cantilever beam, such as an airplane propeller or turbine blade, are developed.



DESIGN FOR DEFENSE

When the U. S. Navy focused attention on the helicopter as a means to combat underwater craft and the new long range Schnorkel-type submarine in particular... Bell Aircraft Corporation stood ready and well qualified to supply the right answer.

Winner of the Navy's recent anti-submarine helicopter competition—was Bell Aircraft, with a design which incorporated important advances developed during a decade of pioneering, engineering and manufacture of rotary wing aircraft.

Bell helicopters are veterans of military service, by all arms of the Defense Department. The Navy has HTL-1s, HTL-2s and HTL-3s for everything from weather investigation to torpedo spotting. Furthermore, it has assigned helicopters to the Marines for liaison and observance work and to the Coast Guard for patrol and rescue missions. The Air Force, the Army Field Forces and the Corps of Engineers also find a multitude of uses for Bell Helicopters.

Back of the achievements of Bell helicopters are 10 years of development, experimentation, testing and product improvement—and more than 100,000 hours of flight time in actual field operations in the United States and 29 foreign countries. The record of these helicopters "in the service of the services", and in other fields of aviation is significant of the high level of Bell Aircraft design and performance.

BELL Aircraft CORPORATION

Pioneer of supersonic aircraft — remote controlled flight — jet and rocket propulsion — rotary wing aircraft — fighter design, armament and construction — guided missiles.

VERSATILITY

New Jobs, New Models..

From these equations the variation in natural frequency with rotational speed may be found, and some simplified methods for finding these curves are shown. The same approach is used for the case of forced vibrations of a blade due to oscillating loading, and the case of vibration in an airplane propeller due to yaw is considered as an example. It is shown that this approach can be expected to give results within about 10 per cent of experimentally measured ones if a rather simplified determination of the aerodynamic forces is permissible, as it is in normal flight.

Structural Load Measurements on Complex Aircraft Components Using Strain-Gage Summation Circuits

By

Maurice A. Walter

Naval Air Experimental Station, Philadelphia

A method for the measurement of incremental structural loads on complex aircraft surfaces without previous knowledge of load distribution is presented. The judicious location of electric strain gages and a suitable electric circuit with a single channel output to a recording mechanism are the means of effecting the measurement. Since the output of the strain-gage circuit is generally fed into an amplifier and then to a recorder, equations for a bridge looking into a high impedance are developed for measuring loads in a complex surface, and application of the equations is illustrated. Both design and experimental data are shown. The electrical equipment used is described. An approach similar to the one presented can be used for other types of strain-gage circuits.

Static test calibrations using the method have indicated a maximum error of 3.7 per cent in a complex surface, such as a horizontal stabilizer of a fighter airplane.

Experimental and Theoretical Studies of Flame Front Stability

By

George H. Markstein

Cornell Aeronautical Laboratory, Inc.

Rich hydrocarbon flames burning in tubes were found to assume a cellular structure in the absence of turbulence in the approach stream. The effects of type of fuel, mixture composition, and pressure on the phenomenon have been studied. A first-order perturbation treatment of flame front stability gave results in qualitative agreement with experiments when the dependence of burning velocity on flame front curvature was taken into account.

..The Navy's P2V

Like other Lockheed aircraft, the Navy's powerful P2V Patrol Bomber, the Neptune, is today far more versatile than its original prototype. The physical changes that this plane has undergone are so advanced they are secret, but the proved achievement of the P2V series is a matter of record.

The P2V holds the world's longest *non-refueling, non-stop* flight record of 11,236 miles—from Perth, Australia, to Columbus, Ohio.

It is the largest airplane to take off from an aircraft carrier.

A squadron of Navy P2V's flew 691 hours photographing the Arctic in an unprecedented aerial survey. They took more than 120,000 separate pictures.

P2V's in the Arctic have operated successfully in extremely adverse cold weather, as cold as −42°F.

Neptunes are currently engaged in vital operations in the Pacific area.

Long in quantity production, the Neptune provides the Navy with a patrol bomber designed for many jobs: anti-submarine warfare, all-weather reconnaissance, including hurricane patrol, long-range photo reconnaissance, air search and rescue, special carrier-launched missions.

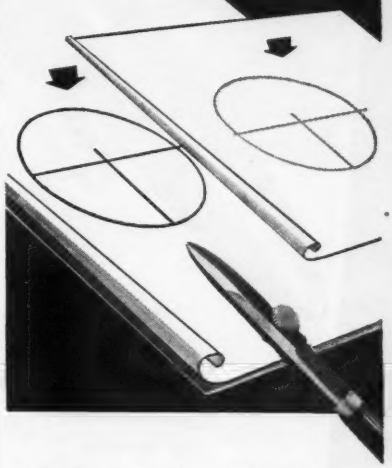
Lockheed Aircraft Corp.

Burburbank, California

Imperial

TRACING CLOTH

THAT DEFIES TIME!



• The renown of Imperial as the finest in Tracing Cloth goes back well over half a century. Draftsmen all over the world prefer it for the uniformity of its high transparency and ink-taking surface and the superb quality of its cloth foundation.

Imperial takes erasures readily, without damage. It gives sharp contrasting prints of even the finest lines. Drawings made on Imperial over fifty years ago are still as good as ever, neither brittle nor opaque.

If you like a duller surface, for clear, hard pencil lines, try Imperial Pencil Tracing Cloth. It is good for ink as well.

Imperial

TRACING CLOTH

SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE

BLASTING BEAUTY!

Sleek, high-speed, powerful—the Martin XB-51 is the Air Force's first postwar plane specifically designed for supporting our ground forces.

carryi
story

Blasting enemy supply lines and installations to help keep our ground forces rolling—that's one of the roles the new Martin XB-51 is designed to play in America's preparedness program! It's a teamwork bomber—versatile, powerful, super-fast, highly maneuverable, designed to be capable of operating from combat area fields. Its lines are clean and graceful, yet radically different. A unique power plant arrangement includes two jets mounted on fuselage pylons and a third in the tail. Drastically sweptback wings, a T-shaped tail and tandem landing gear—plus many other features still classified under military security regulations—make it as modern as tomorrow!

Like all Martin developments, the XB-51 is the product of a highly skilled engineering team. Electronic, aerodynamic, metallurgy research, servo-mechanism studies—all play their parts in the technical leadership Martin offers its customers today. All play their parts as Martin extends research frontiers in advanced design aircraft, rocketry, jet propulsion, supersonic missiles and other far-reaching fields! THE GLENN L. MARTIN COMPANY, Baltimore 3, Maryland.

Powered for faster starts, the Martin XB-51 is designed to have great versatility for operations to and from smaller combat area fields. For landings, the new Martin bomber has a parachute stowed aft which may be released

at the pilot's discretion for more rapid deceleration.

Martin
AIRCRAFT
Builders of Dependable Aircraft Since 1909

Manufacturers of: Military aircraft • Martin airliners • Guided missiles • Rockets • Electronic fire control and radar systems • Precision testing instruments **Developers and Licensors of:** Mareng fuel tanks (to U. S. Rubber Co.) • Marform metal-forming (to Hydropress, Inc.) • Honeycomb construction material (to U. S. Plywood Corp. and Aircraft Die Cutters) • Structural adhesives (to U. S. Plywood Corp. and Bloomingdale Rubber Co.) • Permanent fabric flameproofing (to E. I. duPont de Nemours & Co.) • Hydraulic automotive and aircraft brake **Leaders in** Building Air Power to Guard the Peace, Air Transport to Serve It.

ing air power's to America

air power to guard the peace, air transport to serve it! That's the story Martin advertising develops for millions of alert American readers. Attention-getting advertisements like this reach the general public and business circles in *Time*, *Newsweek* and *Business Week* . . . explain aviation's important role in our country's preparedness program and in the development of travel facilities. "Martin Air Memos" bring news of latest developments to the men and women who write and edit the news through *Editor and Publisher*, *American Press* and *Publisher's Auxiliary*.

engineering has become food for discussion even among laymen in this highly technical age. So this advertising also highlights the manner in which Martin *systems engineering* is meeting the challenge of tremendously complicated air power needs. Today, the Martin engineering staff is designing aircraft and missiles as integrated air-borne systems, not merely as flying vehicles. Martin design work embodies electronic flight and navigational controls and military armament or passenger facilities, as well as airframe and power plant. And the complete development of the aircraft or missile is so scheduled that the end product represents a completely coordinated system.

A well-informed public . . . fully aware of preparedness needs, problems and measures . . . is one of the finest safeguards for peace. Martin advertising helps spread the facts!

THE GLENN L. MARTIN COMPANY, Baltimore 3, Maryland.

Martin
AIRCRAFT

Builders of Dependable Aircraft Since 1909

Nobody throws away Stainless Steel

Stainless steel *lasts*. Allegheny Metal stays bright and strong —gives lifetime service—under conditions of corrosion, heat and wear that send lesser metals to the junk-pile in a few years, or perhaps only months. Wherever a superior metal will give you advantage, you'll find it cheapest in the long run to use Allegheny Metal, the time-tested stainless steel.

Complete technical and fabricating data—engineering help, too—yours for the asking. W&D 2139

ALLEGHENY LUDLUM STEEL CORPORATION

The Nation's Leading Producer of Stainless Steel in All Forms

AL

Pittsburgh, Pa. . . . Offices in Principal Cities

Allegheny Metal is stocked by all Jos. T. Ryerson & Son, Inc., Warehouses

Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

I. PERIODICALS AND REPORTS

The abstracts are classified according to the Air Technical Index Distribution Guide. Numbers in parentheses indicate the position of the Division Headings in the numerical arrangement.

Aerodynamics (2)
- Aerodynamic Loads ... 58
- Boundary Layer ... 58
- Control Surfaces ... 58
- Fluid Mechanics & Aerodynamic Theory ... 59
- Internal Flow ... 60
- Parasitic Components & Interference ... 60
- Performance ... 60
- Stability & Control ... 60
- Wings & Airfoils ... 60

Air Transportation (41) ... 62

Airplane Design & Description (10) ... 62
- Airplane Descriptions ... 62
- Landing Gear ... 62

Airports (39) ... 62

Aviation Medicine (19) ... 62

Electronics (3) ... 62

Engineering Practices (49) ... 62

Flight Operating Problems (31)
- Ice Prevention & Removal ... 62

Flight Safety & Rescue (15) ... 62

Flight Testing (13) ... 62

Fuels & Lubricants (12) ... 64

Gliders ... 64

Guided Missiles (1) ... 64

Instruments (9) ... 64

Laws & Regulations (44) ... 64

Machine Elements (14)
- Friction ... 64
- Shafts & Rotating Discs ... 64

Maintenance (25) ... 66

Materials (8)
- Metals & Alloys ... 66
- Nonmetallic Materials ... 66
- Protective Coatings ... 66

Meteorology (30) ... 66

Navigation (29) ... 66

Photography (26) ... 66

Power Plants ... 68
- Jet & Turbine (5) ... 68
- Reciprocating (6) ... 68

Production (36) ... 68

Propellers (11) ... 70

Rotating Wing Aircraft (34) ... 70

Sciences, General (33)
- Mathematics ... 70
- Mechanics ... 70
- Mechanics—Vibration ... 70

Space Travel ... 70

Structures (7) ... 70

Thermodynamics (18) ... 74

Water-Borne Aircraft (21) ... 89

Wind Tunnels (17) ... 89

II. BOOKS REVIEWED IN THIS ISSUE

Scientific Research. Edited by G. P. Bush and L. H. Hattery ... 77
Reviewed by C. C. Furnas, Cornell Aeronautical Laboratory, Inc.

The Properties of Metallic Materials at Low Temperatures. P. L. Teed ... 77
Reviewed by William Schroeder, Lockheed Aircraft Corporation

Book Notes ... 78

Books, reports, and periodicals reviewed in this issue or in previous issues may be borrowed on 2-week loan without charge by individual or Corporate Members of the Institute in the U.S. and Canada. Members of The Paul Kollsman Lending Library who are not Members of the Institute may borrow books and, in special cases, other research material. Members of the I.A.S. may borrow also from the Engineering Societies Library through The Paul Kollsman Lending Library.

Photostatic copies of material in the Institute's libraries may be obtained at a cost of $0.30 to members and Corporate Members ($0.40 to nonmembers) for each 8½- by 11-in. print and $0.35 to members and Corporate Members ($0.45 to nonmembers) for each 11½- by 14-in. print, plus postage. A service charge of $1.00 is made to nonmembers of the I.A.S. Rates for *microfilm copies* will be sent on request.

Bibliographies on special subjects will be compiled at the rate of $2.50 per hour. *Translations* of technical literature from foreign languages may be obtained at $12 to $14 per 1,000 words, depending on the language. I.A.S. members receive a 20 per cent discount on bibliographies and translations.

Full information about library membership and facilities will be sent upon request to The Paul Kollsman Lending Library, 2 East 64th St., New York 21, N.Y.

AVICA

Specialists in Flexible Pipes

SYNTHETIC HOSE • METALLIC HOSE

FOR ALL FLUID SYSTEMS THROUGHOUT A WIDE TEMPERATURE RANGE

● Avica Synthetic Rubber and flexible metal hose with integral angle couplings.

● Avica Swivel Flange couplings for aluminum and stainless steel tubing.

● Avica Fire Resistant support clamps for flexible and rigid pipes and electric cables.

● Avica Special Design assemblies to solve awkward installation problems.

THERE IS AN AVICA HOSE ASSEMBLY FOR EVERY AVIATION APPLICATION.

SEND US BLUE PRINTS OR SKETCHES AND OUR ENGINEERING DEPARTMENT WILL DESIGN A HOSE ASSEMBLY TO FIT YOUR REQUIREMENT.

AVICA CORPORATION
PORTSMOUTH, NEWPORT, RHODE ISLAND

IN EUROPE
AVICA EQUIPMENT, Ltd.
50 PALL MALL
LONDON, S.W.1, ENGLAND

TRADE MARK

Aerodynamics (2)

AERODYNAMIC LOADS

Estimation of Critical Mach Number. I. G. H. Lee. *The Aeroplane*, Vol. 79, No. 2042, July 28, 1950, pp. 110–113, illus.

General methods by which the high Mach Number isobar pattern may be obtained either from theory or from low Mach Number wind-tunnel tests and a method for calculating the critical Mach Number from the high Mach Number isobar pattern.

Flight Investigation of the Effect of Transient Wing Response on Measured Accelerations of a Modern Transport Airplane in Rough Air. C. C. Shufflebarger and Harry C. Mickleboro. *U.S., N.A.C.A., Technical Note No. 2150*, August, 1950. 18 pp., illus. 1 reference.

BOUNDARY LAYER

Analysis of the Effects of Boundary-Layer Control on the Power-Off Landing Performance Characteristics of a Liaison Type of Airplane. Elmer A. Horton, Laurence K. Loftin, Jr., and Stanley F. Racisz. *U.S., N.A.C.A., Technical Note No. 2143*, August, 1950. 51 pp., illus. 14 references.

Investigation of Boundary-Layer Control to Improve the Lift and Drag Characteristics of the NACA 65_2-415 Airfoil Section with Double Slotted and Plain Flaps. Elmer A. Horton, Stanley F. Racisz, and Nicholas J. Paradiso. *U.S., N.A.C.A., Technical Note No. 2149*, August, 1950. 63 pp., illus. 8 references.

Investigation of Separation of the Turbulent Boundary Layer. G. B. Schubauer and P. S. Klebanoff. *U.S., N.A.C.A., Technical Note No. 2133*, August, 1950. 57 pp., illus. 17 references.

A General Integral Form of the Boundary-Layer Equation for Incompressible Flow with an Application to the Calculation of the Separation Point of Turbulent Boundary Layers. Neal Tetervin and Chia Chiao Lin. *U.S., N.A.C.A., Technical Note No. 2158*, August, 1950. 63 pp., illus. 17 references.

Contributions to the Theory of Heat Transfer Through a Laminar Boundary Layer. M. J. Lighthill. *Royal Society (London), Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 202, No. 1070, August 7, 1950, pp. 359–377, illus. 9 references.

An approximation to the heat-transfer rate across a laminar incompressible boundary layer for arbitrary distribution of mainstream velocity and of wall temperature is obtained by using the energy equation in von Mises form and approximating the coefficients in a manner that is most closely correct near the surface. By the use of known transformations, an expression is derived for heat transfer to a surface with arbitrary temperature distribution along it and with a uniform main stream outside it at arbitrary Mach Number. The temperature distribution that is obtained along a surface in the case when heat transfer is balanced entirely by radiation from it gives higher temperatures near the nose and lower temperatures farther back than are found from a theory that assumes the wall temperature uniform and averages the heat transfer balance.

Obobshchennoe Integral'noe Sootnoshenie dlia Teplogo Pogranichnogo Sloia i ego Primenenie k Raschety Teploobmena. L. I. Kudriashev. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 63, No. 1, November 1, 1948, pp. 23–25. 5 references. (In Russian.) A generalized integral correlation for the heated boundary layer and its application to the calculation of heat exchange.

Laminar-Boundary-Layer Heat Transfer Characteristics of a Body of Revolution with a Pressure Gradient at Supersonic Speeds. William R. Wimbrow and Richard Scherrer. *U.S., N.A.C.A., Technical Note No. 2148*, August, 1950. 23 pp., illus. 8 references.

Approximate Solution of Compressible Fluid-Flow Problems by Galerkin's Method. Chi-Teh Wang and R. F. Brodsky. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 660–666, illus. 14 references.

CONTROL SURFACES

Lateral-Control Devices Suitable for Use with Full-Span Flaps. Francis M. Rogallo, John G. Lowry, and Jack Fischel. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 629–638, 652, illus. 41 references.

Supersonic Characteristics of Rectangular Horn Balanced Ailerons. Charles W. Coale. *Douglas Aircraft Company, Inc.*,

Report No. SM-13718, March 31, 1950. 32 pp., illus. 3 references.

A rapid means of calculating the horn balanced aileron characteristics at supersonic speeds which uses extensions of the nonviscous linearized theory of lifting strips and provides general formulas for the lift, rolling moment, and hinge moment. Study of a typical aileron shows that good balance can be obtained without large variation of hinge moment-rolling moment ratio with Mach Number. Viscosity, gaps, etc., will have effects that must be determined experimentally.

FLUID MECHANICS & AERODYNAMIC THEORY

Some Problems of Flow Behind Shocks of Varying Strength. C. C. Lin. (*Symposium on Shock-Wave Phenomena*, June 30, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1135*, July 1, 1950, pp. 13–23, illus. 8 references.

Theoretical discussions of the possibility of a normal shock over a curved solid boundary, the curved shock attached to the nose of a body of revolution placed in a supersonic stream, and the detached shock in front of a two-dimensional body or body of revolution.

An Experimental Study of the Interaction of Shock Waves. Walker Bleakney. (*Symposium on Shock-Wave Phenomena*, June 30, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1135*, July 1, 1950, pp. 25–35, illus. 6 references.

Measurement of the density field in the neighborhood of the intersections of the known discontinuities that occur in the reflection of shock waves on a rigid wall. A series of pictures taken with an interferometer adjusted for a single fringe in the undisturbed field, in which only the angle of incidence varies, shows that the density is uniform in the three angular domains about the point of intersection. As the angle of incidence approaches 90°, the pattern conforms to the solution obtained by Bargmann for the hydrodynamic problem for nearly glancing incidence.

On Shock-Wave Phenomena: Waterlike Substances. R. J. Seeger and H. Polachek. (*Symposium on Shock-Wave Phenomena*, June 30, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1135*, July 1, 1950, pp. 37–82, illus. 8 references.

A theoretical discussion of the influence of thermodynamic factors on shock-wave phenomena that occur during the interaction of shock waves in substances that behave like water.

Impact Shock Waves in Water. J. H. McMillen. (*Symposium on Shock-Wave Phenomena*, June 30, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1135*, July 1, 1950, pp. 83–98, illus.

Experimental investigation undertaken at the U.S. Naval Ordnance Laboratory on the shock waves produced in liquid and solid media by the entrance of missiles at subsonic and supersonic velocities.

Shock-Wave Phenomena in Astronomy. Z. Kopal. (*Symposium on Shock-Wave Phenomena*, June 30, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1135*, July 1, 1950, pp. 1–11, illus. 12 references. Novae phenomena explained as the interaction of a series of shock waves caused by an explosion in the star.

Transonic Flow and Generalized Axially Symmetric Potential Theory. Alexander Weinstein. (*Symposium on Theoretical Compressible Flow*, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1132*, July 1, 1950, pp. 73–82, illus. 7 references.

A new approach to the application of the hodograph method to the theory of plane, irrotational, isentropic flow of an ideal gas. By using generalized axially symmetric potential theory as a basis, some flows that satisfy prescribed boundary conditions can be dealt with.

Aerodynamic Similarity at Axisymmetric Transonic Flow Around Slender Bodies. K. Oswatitsch and S. B. Berndt. *Sweden, Kungl. Tekniska Högskola, Institution för Flygteknik, Technical Note No. KTH-AERO TN 15*, May 11, 1950. 10 pp., illus. 9 references.

The similarity laws that are derived for transonic flow around slender bodies of revolution permit the comparison of the pressure distributions on two bodies when the free-stream velocity for the two bodies is either supersonic, sonic, or subsonic. The form of these laws is such that the pressure distributions for bodies with affined relative thickness and free-stream Mach Number are not similar but are obtained from one another by transformation by means of a formula containing the second derivative of the variable cross-section area along the body. Application to slightly supersonic flow around slender cones shows good agreement with exact theory.

Water and Supersonic Aerodynamics. H. W. S. La Vier. *The Research Engineer*, March, 1950, pp. 3, 4, 17–20, illus. 5 references. Description of the 20- × 4-ft. shallow water channel used at the Georgia Institute of Technology as a hydraulic analog in the study of supersonic aerodynamics.

The Effect of Compressibility on the Flow Around Slender Bodies of Revolution. Klaus Oswatitsch. *Sweden, Kungl. Tekniska Högskola, Institution för Flygteknik, Technical Note No. KTH-AERO 12*, February 14, 1950. 8 pp., illus. 3 references.

A simple logarithmic relation is established between the Mach Number and the change of velocity distribution on a slender body of revolution in subsonic and supersonic flow. The relation is always valid when the potentials are given by the distribution of the body's cross sectional area. Total pressure drag minus base pressure drag in supersonic flow is independent of Mach Number when the body has a cylindrical rear end.

Approximate Solution of Compressible Fluid-Flow Problems by Galerkin's Method. Chi-Teh Wang and R. F. Brodsky. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 660–666, illus. 14 references.

The Bases and Scope of the Linearized Theory of Compressible Fluid Flow with Special Reference to Steady Supersonic Flow. G. N. Ward. (*Symposium on Theoretical Compressible Flow*, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1132*, July 1, 1950, pp. 35–41.

On the Particular Integrals of the Prandtl-Busemann Iteration Equations for the Flow of a Compressible Fluid. Carl Kaplan. *U.S., N.A.C.A., Technical Note No. 2159*, August, 1950. 16 pp. 3 references.

Remarks on Combined Effects of Viscosity and Compressibility. P. A. Lagerstrom. (*Symposium on Theoretical Compressible Flow*, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1132*, July 1, 1950, pp. 53–59. 8 references.

A discussion of the linearized Navier-Stokes equation for a compressible fluid, neglecting heat conduction, illustrates the approach used at the Guggenheim Aeronautical Laboratory at Cal Tech in the study of viscous waves. The investigation started with the simplest examples of such waves and proceeded gradually to the more complicated cases. In each case, a qualitative comparison was attempted between the idealized case and the real fluid.

Two-Dimensional Compressible Flows Having Arbitrarily Specified Pressure Distributions for Gases with Gamma Equal to Minus One. Francis H. Clauser. (*Symposium on Theoretical Compressible Flow*, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1132*, July 1, 1950, pp. 1–33, illus. 7 references.

An investigation of the transformation from the hodograph to the real plane which provides a method for designing both simple airfoils and airfoils with scoops, slots, air-exhaust ports, cowl flaps, and boundary-layer injectors when the flow is two-dimensional and compressible and the velocity distribution is specified. The method can be extended to cover flows in two-dimensional ducts with simple contraction and turn and in ducts with joining and parting flows.

The Rankine Gas Flow in the Hodograph Plane. Max M. Munk. (*Symposium on Theoretical Compressible Flow*, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1132*, July 1, 1950, pp. 43–51. 3 references.

The hodograph solution for a perfect gas arriving with subsonic velocity and flowing past the head of an obstacle that extends infinitely far downstream. The stream function in the physical potential and the Legendre reciprocal potential in the hodograph plane, which is associated with a reciprocal stream function, are used.

Readers' Forum: On Virtual Mass and Wave Drag at Subsonic Speeds. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 667, 668. 2 references.

Nekotorye Tochnye Resheniia Uravnenii Gasovoi Dinamiki dlia Tsentral'no-Simmetrichnykh Dvizhenii. K. P. Staniukovich. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 60, No. 7, June 1, 1948, pp. 1141–1144. 2 references. (In Russian.) Some exact solutions of equations of gas dynamics for centrally symmetric flow, taking into account entropy variation.

O Nekotorykh Dvizheniiakh Gaza s Peremennoi Entropiei i Polnoi Energiei. IU. V. Rudnev. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 49, No. 5, February

11, 1948, pp. 869, 870. 1 reference. (In Russian.) On some motions of a gas with variable entropy and total energy. The plane parallel steady adiabatic motion of an ideal perfect gas is investigated.

Svedenie Uravnenii Izotermicheskikh Gazovykh Techenii k Kvadraturam. A. M. Fainzil'ber. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 62, No. 5, October 11, 1948, pp. 603–606. 4 references. (In Russian.) Reduction of the equations of isothermal gas flows to quadratures.

INTERNAL FLOW

Vliianie Vneshnogo Treniia na Obrazovanie Udarnykh Voln v Tsilindricheskikh Trubakh. E. V. Stupochenko. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 49, No. 6, February 21, 1948, pp. 1073–1076. 1 reference. (In Russian.) The influence of internal friction on the formation of shock waves in cylindrical tubes.

Raschet Profil'nykh Poter' Reaktivnykh Turbinnykh i Kompressornykh Reshetok pri Bezotryvnom Ikh Obtekanii Potokom Gaza. N. M. Markov. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 60 (N.S.), No. 4, May 1, 1948, pp. 555–558, illus. 2 references. (In Russian.) Theoretical calculation of the profile losses of reaction-turbine and compressor cascades in uninterrupted flow.

Readers' Forum: On Boundary-Layer Growth in a Compressible Flow Between Radial Walls. J. Conrad Crown. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, p. 667. 1 reference.

PARASITIC COMPONENTS & INTERFERENCE

Base Drag and Thick Trailing Edges. Sighard F. Hoerner. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 622–628, illus. 21 references.

PERFORMANCE

Analysis of the Effects of Boundary-Layer Control on the Power-Off Landing Performance Characteristics of a Liaison Type of Airplane. Elmer A. Horton, Laurence K. Loftin, Jr., and Stanley F. Racisz. *U.S., N.A.C.A., Technical Note No. 2143*, August, 1950. 51 pp., illus. 14 references.

STABILITY & CONTROL

The Complex Frequency Method of Stability Analysis; Application to an Automatically Controlled Pilotless Model Aircraft. B. E. Swire. *Australia, Department of Supply and Development, Aeronautical Research Laboratories, Report No. I. 18*, February, 1950. 58 pp., illus. 9 references.

The complex-frequency method is similar to the frequency-response method but is directly applicable to the stability of an aircraft with or without automatic control. The design of an instrument for installation in a pilotless model aircraft in order to improve its stability in azimuth is used to show the usefulness of the method in the synthesis of automatic control instruments.

An Apparatus for Varying Effective Dihedral in Flight with Application to a Study of Tolerable Dihedral on a Conventional Fighter Airplane. William M. Kauffman, Charles J. Liddell, Jr., Allan Smith, and Rudolph D. Van Dyke, Jr. *U.S., N.A.C.A., Report No. 948*, 1949. 16 pp., illus. 8 references. U.S. Govt. Printing Office, Washington. $0.20.

Effect of an Unswept Wing on the Contribution of Unswept-Tail Configurations to the Low-Speed Static- and Rolling-Stability Derivatives of a Midwing Airplane Model. William Letko and Donald R. Riley. *U.S., N.A.C.A., Technical Note No. 2175*, August, 1950. 47 pp., illus. 11 references.

A Simplified Method for the Determination and Analysis of the Neutral-Lateral-Oscillatory-Stability Boundary. Leonard Sternfield and Ordway B. Gates, Jr. *U.S., N.A.C.A., Report No. 943*, 1949. 12 pp., illus. 7 references. U.S. Govt. Printing Office, Washington. $0.15.

The Quasi-Steady Air Forces for Use in Low-Frequency Stability Calculations. Martin Goland. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 601–608, 672, illus. 15 references.

Appreciation and Prediction of Flying Qualities. William H. Phillips. *U.S., N.A.C.A., Report No. 927*, 1949. 44 pp., illus. 41 references. U.S. Govt. Printing Office, Washington. $0.30.

WINGS & AIRFOILS

An Approximate Method for Determining the Incompressible, Irrotational Flow Around a Symmetrical Wing Section. S. B. Berndt. *Sweden, Kungl. Tekniska Högskola, Institution för Flygteknik, Technical Note No. KTH-AERO TN 7*, July 10, 1949. 18 pp., illus. 3 references.

Starting from the Theodorsen method of conformally mapping an arbitrary wing section upon a circle, an approximate expression is obtained for the singularity distribution on the axis of a symmetrical wing section in incompressible, irrotational flow. By expanding the singularity distribution into a series, the stream function and the velocity field around the wing section are computed. The necessary functions are tabulated.

Similarity Laws for Transonic Flow Around Wings of Finite Aspect Ratio. S. B. Berndt. *Sweden, Kungl. Tekniska Högskola, Institution för Flygteknik, Technical Note No. KTH-AERO TN 14*, February 20, 1950. 8 pp. 5 references.

The similarity laws that govern the relationship between relative profile thickness and free-stream Mach Number for similar pressure distributions are generalized for wings of finite aspect ratio. A similarity law is given for swept-back wings at supersonic speeds which takes into consideration the transonic nature of the flow when the Mach Number component perpendicular to the wing direction approximates unity.

Charts for Estimating Downwash Behind Rectangular, Trapezoidal, and Triangular Wings at Supersonic Speeds. Rudolph C. Haefeli, Harold Mirels, and John L. Cummings. *U.S., N.A.C.A., Technical Note No. 2141*, August, 1950. 67 pp., illus. 12 references.

Transient Loading of Supersonic Rectangular Airfoils. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 647–652, illus. 6 references.

Readers' Forum: Some Relations Between Harmonic and Transient Loading of Airfoils. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 670, 671. 3 references.

Comparison Between Theoretical and Experimental Lift Distributions of Plane Delta Wings at Low Speeds and Zero Yaw. S. B. Berndt and K. Orlik-Rückemann. *Sweden, Kungl. Tekniska Högskola, Institution för Flygteknik, Technical Note No. KTH-AERO TN 10*, December 15, 1948. 25 pp., illus. 15 references.

Calculation, according to variations of Faulkner's method, of the lift distribution at zero yaw and low speeds of six plane delta wings of aspect ratio 0.5 to 2.5. The method involved a layout with 126 vortices and 6 control points. Allowance is made for the discontinuity in the direction of the leading edge at the wing center. A parabolic basic distribution of vorticity is assumed for preliminary calculations on the triangular wings, and Faulkner's elliptic distribution is used for the final calculations. Comparison with experimental results shows fairly good agreement at small angles of attack. The most important deviation can be attributed to the influence of the finite thickness of the wing, which is neglected in the theory.

Low-Speed Investigation of the Stalling of a Thin, Faired, Double-Wedge Airfoil with Nose Flap. Leonard M. Rose and John M. Altman. *U.S., N.A.C.A., Technical Note No. 2172*, August, 1950. 27 pp., illus. 5 references.

The Calculation of Downwash Behind Wings of Arbitrary Plan Form at Supersonic Speeds. John C. Martin. *U.S., N.A.C.A., Technical Note No. 2135*, July, 1950. 47 pp., illus. 12 references.

On the Effect of Subsonic Trailing Edges on Damping in Roll and Pitch of Thin Sweptback Wings in a Supersonic Stream. Herbert S. Ribner. *U.S., N.A.C.A., Technical Note No. 2146*, August, 1950. 27 pp., illus. 8 references.

Measurements of Section Characteristics of a 45° Swept Wing Spanning a Rectangular Low-Speed Wind Tunnel As Affected by the Tunnel Walls. Robert E. Dannenberg. *U.S., N.A.C.A., Technical Note No. 2160*, August, 1950. 42 pp., illus. 5 references.

Wind-Tunnel Investigation at Low Speed of a 45° Sweptback Untapered Semispan Wing of Aspect Ratio 1.59 Equipped with Various 25-Percent-Chord Plain Flaps. Harold S. Johnson and John R. Hagerman. *U.S., N.A.C.A., Technical Note No. 2169*, August, 1950. 26 pp., illus. 11 references.

NAVY adds new logistic support!

Douglas DC-6 enters military service

To meet the need for increasing air lift, the U. S. Navy has ordered a fleet of R6D-1 aircraft.

This is the Navy's designation for the DC-6A *Liftmaster* which was developed from the world-famous Douglas DC-6 passenger transport.

On long missions this 320 mph airplane has double the cargo capacity of the R5D (C-54), yet it is one-third less costly to operate, takes one-fourth less manpower.

In the R6D-1, Douglas provides a ready answer to an urgent military need for a high-speed, long-range, *dependable* air transport.

DOUGLAS AIRCRAFT COMPANY, INC., SANTA MONICA, CALIFORNIA

DEPEND ON DOUGLAS

30TH ANNIVERSARY YEAR

Some Conical and Quasi-Conical Flows in Linearized Supersonic-Wing Theory. Herbert S. Ribner. *U.S., N.A.C.A., Technical Note No. 2147*, August, 1950. 61 pp., illus. 21 references.

The Quasi-Steady Air Forces for Use in Low-Frequency Stability Calculations. Martin Goland. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 601–608, 672, illus. 15 references.

Air Transportation (41)

United States Overseas Air Cargo Services. V. N. W. Kendall. *Air Transportation*, Vol. 17, No. 2, August, 1950, pp. 12, 13, 16, 17, illus.

Air Express vs. Railway Express. William B. Lanham, Jr. *Air Transportation*, Vol. 17, No. 2, August, 1950, pp. 10, 11, 21, 22, illus.

Proper Packaging Means Money in the Bank. *Air Transportation*, Vol. 17, No. 2, August, 1950, pp. 18, 19, 22–24, illus.

Food for Flying; Development of Airline Catering. G. F. Wills. *Shell Aviation News*, Vol. 19, No. 145, July, 1950, pp. 8–11, illus.

Airplane Design & Description (10)

Conception et Étude des Prototypes. A. Buret. *Technique et Science Aéronautiques*, No. 2, 1950, pp. 119–128, illus. The design and study of prototype aircraft.

AIRPLANE DESCRIPTIONS

Avro (Canada) C.102 Jetliner Turbojet Transport. J. C. Floyd (*S.A.E. Annual Meeting, Detroit, January 9–13, 1950, Preprint.*) *Aircraft Engineering*, Vol. 22, No. 258, August, 1950, pp. 228–237, illus. A summary of the design and general problems that were encountered in the development of the first prototype up to the flight-test stage. *Shell Aviation News*, Vol. 19, No. 145, July, 1950, pp. 14–16, illus. Ground and flight trials.

Das Fliegende Auto KF-3. H. Holzbauer. *Weltluftfahrt*, Vol. 1, No. 10, April, 1950, p. 217, illus. Proposed design for a roadable airplane.

Pulqui II Turbojet Fighter, Argentina. *Aviation Week*, Vol. 53, No. 8, August 21, 1950, p. 21, illus.

SAAB-29 Turbojet Fighter, Sweden. Lars Brising. *Saab Sonics*, No. 10, April–June, 1950, pp. 2–7, 24, 25, illus. A development history.

S.N.C.A. du Sud-Est SE.2010 Armagnac Four-Engined Transport, France. *Modern Transport*, Vol. 63, No. 1635, July 29, 1950, p. 3, illus. Test flight impressions.

S.N.C.A. du Sud-Ost SO.30 Bretagne Twin-Motor Transport, France. *L'Air*, Vol. 31, No. 639, May, 1950, pp. 18–24, illus., cutaway drawing.

Warren-Young Skycar Tailless Aircraft, England. Norman Hall-Warren. *Flight*, Vol. 58, No. 2172, August 10, 1950, pp. 179–181, illus.

Yak 16 Twin-Engined Feederline Transport, U.S.S.R. *Aviation Week*, Vol. 53, No. 8, August 21, 1950, p. 33, illus.

LANDING GEAR

K Voprosu Kacheniia Kolesa s Elastichnoi Shinoi. I. I. Metelitsyn. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 61, No. 3, July 21, 1948, pp. 449–452, illus. 5 references. (In Russian.) The rolling of a wheel with a resilient tire.

Airports (39)

Jets and Air Traffic Control. I. John Longhurst. *The Aeroplane*, Vol. 79, No. 2044, August 11, 1950, pp. 168–171, illus. The effect of the increased speed of jet aircraft and the problems of tropopause meteorology upon the vertical and lateral separation required in traffic patterns.

Airport Design and the All Weather Navigation Program. Walther Prokosch. *Airport Operators Council, Annual Meeting, Cleveland, April 25, 1950, Preprint.* 8 pp., illus.

Interlock—Newest Traffic Control Aid. William D. Perreault. *American Aviation*, Vol. 14, No. 6, August 15, 1950, pp. 29–31, illus.

Aviation Medicine (19)

Altitude Lung Sickness—A Chronic Result of Aeroembolism? Lennart Stenström. *Saab Sonics*, No. 10, April–June, 1950, pp. 20, 21, 19, 25, illus.

Importancia del Estudio del Aparato Cardiovascular en Relación con la Aptitud de Vuelo. Hernán Fuentes Fuentes. *Revista de la Fuerza Aérea*, Vol. 10, No. 35, January–March, 1950, pp. 15–23.

Electronics (3)

Current Distributions on Transmitting and Receiving Antennas. T. Morita. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 8, August, 1950, pp. 898–904, illus. 10 references.

Input Impedance of a Slotted Cylinder Antenna. Charles A. Holt. *Illinois, University, Bulletin*, Vol. 47, No. 51 (*Engineering Experiment Station, Circular Series No. 59*), March, 1950. 50 pp., illus. 6 references.

A Crystal Amplifier with High Input Impedance. Otmar M. Stuetzer. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 8, August, 1950, pp. 868–871, illus. 7 references.

Microspacer Electrode Technique. Otmar M. Stuetzer. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 8, August, 1950, pp. 871–876, illus. 1 reference.

Noise Levels in the American Sub-Arctic. N. C. Gerson. *Institute of Radio Engineers, Proceedings*, Vol. 38, No. 8, August, 1950, pp. 905–916, illus. 10 references.

A New Approach to Aircraft Radio; Developments by Nav-Rad Ltd. *Airports and Air Transportation*, Vol. 5, No. 83, July, 1950, pp. 67, 68, illus.

Engineering Practices (49)

K Chislennomu Resheniiu Nekotorykh Zadach Analiza na Tabuliatorakh Vertikal'no-Gorizontal'nogo Deistviia. K. A. Karpov. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 62, No. 6, October 21, 1948, pp. 741–744. 6 references. (In Russian.) Numerical solution of some problems of analysis on tabulators of vertical-horizontal action.

Analog Computer Aids Plane Design. *Aviation Week*, Vol. 53, No. 8, August 21, 1950, pp. 37, 38, 40, illus. The operation of the electric analog computer of the Analysis Laboratory at California Institute of Technology.

Flight Operating Problems (31)

ICE PREVENTION & REMOVAL

Photomicrographic Investigation of Spontaneous Freezing Temperatures of Supercooled Water Droplets. Robert G. Dorsch and Paul T. Hacker. *U.S., N.A.C.A., Technical Note No. 2142*, July, 1950. 55 pp., illus. 11 references.

Flight Safety & Rescue (15)

Fatal Accidents and Weather (Non-Air Carriers); Calender Years 1948 and 1949. *U.S., C.A.A.*, May, 1950. 16 pp., illus. An analysis of C.A.B. statistics on nonair-carrier accidents in which Visual Flight Rule flying was continued into instrument weather.

Aviation Fuels and Fire Hazards. *Shell Aviation News*, Vol. 19, No. 145, July, 1950, p. 17, illus.

Safety Equipment Pays Off. William H. Shockey. *U.S. Air Services*, Vol. 32, May, 1950, pp. 11, 12, illus. The 40*g* harness and seat installation developed by the Navy Bureau of Aeronautics for installation in naval aircraft.

Device Warns of Engine Failure; SAAB's Improved Magnetic Sump Plug Gives Early Warning of Breakdown. *Aviation Week*, Vol. 52, No. 20, May 15, 1950, p. 45, illus.

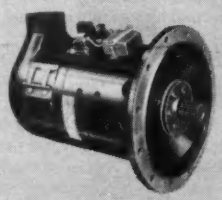
Flight Testing (13)

An Apparatus for Varying Effective Dihedral in Flight with Application to a Study of Tolerable Dihedral on a Conventional Fighter Airplane. William M. Kauffman, Charles J. Liddell, Jr., Allan Smith, and Rudolph D. Van Dyke, Jr. *U.S., N.A.C.A.,*

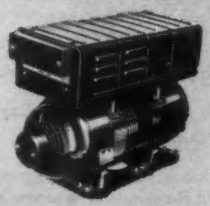
J&H

meeting your needs with proved . . .

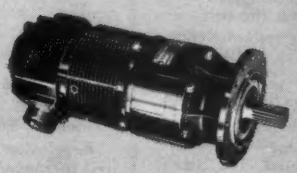
PACKAGES OF POWER



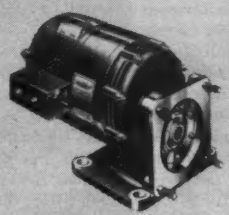
GENERATORS



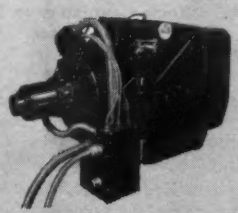
INVERTERS



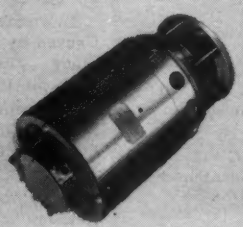
ACTUATORS



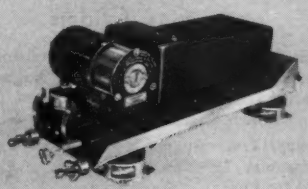
AIRCRAFT MOTORS



AUXILIARY POWER UNITS



STARTERS



ELECTRICAL CONTROL SYSTEMS

These are but a few of the types of aircraft electrical equipment now in production at J & H. They're units we've successfully developed and engineered . . . based on your demands —for smaller, lighter, more dependable packages of power.

J&H

JACK & HEINTZ

PRECISION INDUSTRIES INC.
CLEVELAND 1, OHIO

Report No. 948, 1949. 16 pp., illus. 8 references. U.S. Govt. Printing Office, Washington. $0.20.

Fuels & Lubricants (12)

Tables of Thermodynamic Functions for Analysis of Aircraft-Propulsion Systems. Vearl N. Huff and Sanford Gordon. *U.S., N.A.C.A., Technical Note No. 2161*, August, 1950. 99 pp., illus. 38 references.

Constant-Pressure Combustion Charts Including Effects of Diluent Addition. L. Richard Turner and Donald Bogart. *U.S., N.A.C.A., Report No. 937*, 1949. 25 pp., illus. 17 references. U.S. Govt. Printing Office, Washington. $0.25.

Aviation Fuels and Fire Hazards. *Shell Aviation News*, Vol. 19, No. 145, July, 1950, p. 17, illus.

Exothermic Decomposition of Nitromethane. W. G. Cass. *Aircraft Engineering*, Vol. 22, No. 258, August, 1950, pp. 238, 239, illus.

An account of laboratory experiments conducted in 1933 in Italy by R. M. Corelli, G. A. Crocco, and Luigi Crocco to determine the suitability of nitromethane as a fuel of stratospheric aircraft engines. Although the experiments gave promising results, they were not confirmed by full-scale tests.

The Inhibition of Foaming. Sydney Ross. *Rensselaer Polytechnic Institute, Bulletin, Engineering and Science Series*, No. 63, May, 1950. 40 pp., illus. 59 references.

A general summary of experimental investigations of foam inhibitions by insoluble antifoaming agents and a review of current industrial problems and practices. Two foam inhibition mechanisms are proposed. In one, fine droplets of the agent enter the liquid film between bubbles and spread as a thick duplex film. The tensions created by the spreading rupture the film. In the other system, a droplet of the agent enters the liquid film between bubbles to produce a mixed monolayer on the surface. Under certain conditions, the monolayer will have less coherence than the original film-stabilizing monolayer and so will lead to destruction of the film.

Mekhanicheskie Svoistva Sinteticheskikh Smazochnykh Masel pri Nizkikh Temperaturakh. P. I. Sanin. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 61, No. 6, August 21, 1948, pp. 1045–1048, illus. 5 references. (In Russian.) Mechanical properties of synthetic lubricating oils at low temperatures.

Gliders

On Sailplanes with Auxiliary Propulsion. III. A. R. Weyl. *Sailplane and Glider*, Vol. 18, No. 8, August, 1950, pp. 185, 186. Descriptions of 15 powered sailplanes of English, Finnish, German, and Polish origin.

Der Spyr V a. August Hug. *Schweizer Aero-Revue*, Vol. 25, No. 1, January, 1950, pp. 31–33, illus. A two-seater glider manufactured by Pilatus-Werken AG.

Guided Missiles (1)

A Method of Determining Some Aerodynamic Coefficients from Supersonic Free-Flight Tests of a Rolling Missile. Ray E. Bolz and John D. Nicolaides. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 609–621, illus. 9 references.

Base Drag and Thick Trailing Edges. Sighard F. Hoerner. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 622–628, illus. 21 references.

Instruments (9)

The Complex Frequency Method of Stability Analysis; Application to an Automatically Controlled Pilotless Model Aircraft. B. E. Swire. *Australia, Department of Supply and Development, Aeronautical Research Laboratories, Report No. I. 18*, February, 1950. 58 pp., illus. 9 references.

The complex-frequency method is similar to the frequency-response method but is directly applicable to the stability of an aircraft with or without automatic control. The design of an instrument for installation in a pilotless model aircraft in order to improve its stability in azimuth is used to show the usefulness of the method in the synthesis of automatic control instruments.

Ob Usloviiakh Kachestva Avtomaticheskogo Regulirovaniia. N. A. Kartvelishvili. *Akademiia Nauk S.S.S.R, Leningrad, Comptes Rendus (Doklady)*, Vol. 61, No. 1, July 1, 1948, pp. 21–23, illus. (In Russian.) On the conditions determining the quality of automatic control.

Kriterii Kachestva Regulirovaniia. V. V. Solodovnikov. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 60, No. 6, May 21, 1948, pp. 977–980, illus. 4 references. (In Russian.) Criteria for evaluating the performance of linear control systems.

Kriterii Otsutstviia Pereregulirovanii i Kriterii Monotonnosti. V. V. Solodovnikov. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 62, No. 5, October 11, 1948, pp. 599–602, illus. 3 references. (In Russian.) Criteria of the absence of overregulation and criteria of monotony.

Eksperimental'noe Opredelenie Teplovoi Inertsii Termoanemometra. S. I. Krechmer. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 61, No. 6, August 21, 1948, pp. 997–1000, illus. 4 references. (In Russian.) Experimental determination of the thermal inertia of a hot-wire anemometer.

A 100,000,000-Frame-per-Second Camera. M. Sultanoff. *Review of Scientific Instruments*, Vol. 21, No. 7, July, 1950, pp. 653–656, illus. 4 references.

Shock waves close to the edge of explosive charges have been photographed at rates in excess of 100,000,000 frames per sec. by using a multislit focal plane shutter that is transported optically across the film plane by a rotating mirror. Linear shutter speeds up to 300 meters per sec. are easily available, and the resulting framing rates, with the proper selection of slit widths, can be varied from 10^8 to 10^9 frames per sec. Each individual frame is composed of a series of lines, and the degree of discontinuity across each frame is proportional to the total number of frames.

Laws & Regulations (44)

The Civil Aeronautics Board's Authority to Grant Experimental Certificates. Richard G. Kahn. *Journal of Air Law and Commerce*, Vol. 17, No. 2, Spring, 1950, pp. 235–239.

Resolution of American Bar Association Urging Strict Liability and Increased Liability Limits in Revisions of Warsaw and Rome Conventions, Adopted February, 1950. Charles T. Lloyd. *Journal of Air Law and Commerce*, Vol. 17, No. 2, Spring, 1950, pp. 225–230.

Taormina Draft Revision of the Rome Convention on Damage Caused by Aircraft to Third Persons on the Surface. Joan H. Stacy. *Journal of Air Law and Commerce*, Vol. 17, No. 2, Spring, 1950, pp. 194–199.

Comments on Taormina Revision of the Rome Convention on Damage Done by Foreign Aircraft to Persons and Property on the Surface. Arnold W. Knauth. *Journal of Air Law and Commerce*, Vol. 17, No. 2, Spring, 1950, pp. 200–211.

Recognition of Foreign Judgments Under Article 15 of Proposed Revision of Rome Convention. John C. Cooper. *Journal of Air Law and Commerce*, Vol. 17, No. 2, Spring, 1950, pp. 212–220.

Exclusive Gasoline Concessions Under the Federal Airport Act of 1946. Peter Nevitt. *Journal of Air Law and Commerce*, Vol. 17, No. 2, Spring, 1950, pp. 240–243.

Machine Elements (14)

FRICTION

O Prirode Dissipativnykh Sil pri Malykh Smeshcheniiakh Soprikasaiushchikhsia Poverkhnosti. B. K. Shembel'. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 49, No. 9, March 21, 1948, pp. 1567–1570, illus. 5 references. On the nature of the dissipative forces in small displacements of contiguous surfaces.

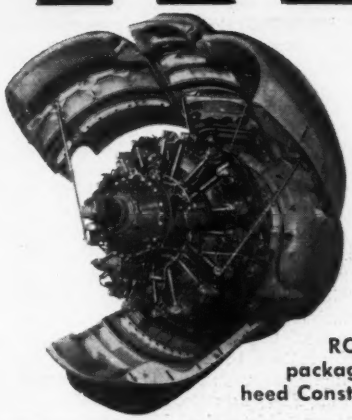
SHAFTS & ROTATING DISCS

Differential Analyzer Solution for the Stresses in a Rotating Bell-Shaped Shell. J. L. Meriam. *Franklin Institute, Journal*, Vol. 250, No. 2, August, 1950, pp. 115–133, illus. 5 references.

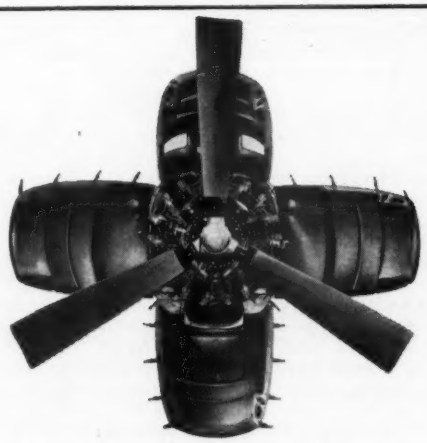
The theory of axially symmetric shells, extended to include the body force of rotation about the axis of generation, is used to obtain the solution for a bell-shaped rotating shell whose middle sur-

ROHR

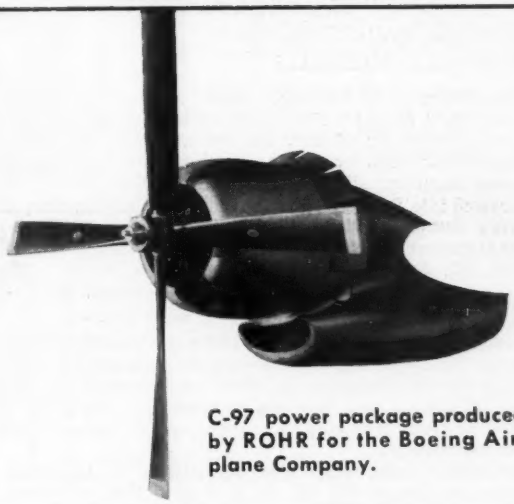
Power package manufactured by ROHR for the Chase C-122 Avitruc Airplane.



ROHR-built power package for the Lockheed Constellation.



Power package built by ROHR for the Convair Liner.



C-97 power package produced by ROHR for the Boeing Airplane Company.

World's largest producer of ready-to-install power packages for airplanes

ROHR
AIRCRAFT CORPORATION in Chula Vista, California... 9 miles from San Diego

face is generated by revolving a circular arc about a tangent line. The defining relation is an ordinary linear differential equation of the fourth order with variable coefficients. A differential analyzer solution was used which involved the problem of handling boundary conditions that were divided between both extremities of the range of the independent variable. The results are compared with those obtained for a conical shell and with the results obtained from membrane theory.

Maintenance (25)

Douglas Service, Vol. 8, No. 4, July-August, 1950. 26 pp., illus. C-47, DC-3, DC-4, DC-6.

Materials (8)

METALS & ALLOYS

The Influence of Stress on Corrosion. I. Julius J. Harwood. *Corrosion,* Vol. 6, No. 8, August, 1950, pp. 249–259, illus. 40 references.

A general review that shows that the influence of stress in corrosion reactions is principally one of localizing the reactions or changing its distribution. The velocity of corrosion is increased by the presence of large stress concentrations at the tip of the corrosion cracks, and failure can be accelerated by purely mechanical effects acting on a reduced cross section.

A Theoretical Investigation of the Effect of Specimen Size in the Measurement of Hardness. R. Hill. *Philosophical Magazine,* Vol. 41, No. 319, August, 1950, pp. 745–753, illus. 6 references.

Mekhanicheskie Svoistva Splavov Sistemy Al-Mg. E. M. Savitskii and M. A. Tylkina. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady),* Vol. 63, No. 1, November, 1948, pp. 49–52, illus. 14 references. (In Russian.) Mechanical properties of aluminum-magnesium alloys.

Les Alliages de Titane dans la Construction Aéronautique. M. Zehnacker. *Technique et Science Aéronautique,* No. 2, 1950, pp. 65–82. 35 references. Proceedings of a conference on aeronautical uses of titanium alloys, French sources of titanium ores, and properties of titanium and titanium alloys.

Materials Engineering File Facts No. 196: Precision Investment Steel Casting Alloys. *Materials & Methods,* Vol. 32, No. 2, August, 1950, pp. 77, 79, illus.

NONMETALLIC MATERIALS

Metal Adhesives for Bonding Aircraft. *Automotive Industries,* Vol. 103, No. 3, August 1, 1950, pp. 38–40, 82, 84, illus. Description of Metlbond, an adhesive film developed by Consolidated Vultee Aircraft Corp. for metal-to-metal bonding of clad aluminum and magnesium alloys.

Research into Rubber; Aircraft-Component Investigations at the New Technical and Scientific Headquarters of the Dunlop World Organization. *Flight,* Vol. 58, No. 2172, August 10, 1950, pp. 171, 172, illus.

PROTECTIVE COATINGS

Methods of Evaluating Aircraft Primers. Edward T. Nelson. *American Society for Testing Materials, Bulletin,* No. 167, July, 1950, pp. 88–90, Discussion, pp. 90–92. 9 references. A brief outline of methods used by Douglas Aircraft Co., Inc., and of some of the special properties necessary to satisfy production and service requirements.

New Hard Coating Gains Wear Applications for Aluminum. *Materials & Methods,* Vol. 32, No. 2, August, 1950, pp. 62–64, illus.

The MHC surface finishing process developed by The Glenn L. Martin Co. A coating is applied to aluminum and aluminum alloys which is nonmetallic, file-hard, highly heat-refractive, and strongly bonded to the base metal.

Meteorology (30)

Photomicrographic Investigation of Spontaneous Freezing Temperatures of Supercooled Water Droplets. Robert G. Dorsch and Paul T. Hacker. *U.S., N.A.C.A., Technical Note No. 2142,* July, 1950. 55 pp., illus. 11 references.

Teoriia Dvizheniia Kapel' v Voskhodiashchem Potoke Nenasyshchennogo ili Peresyshchennogo Parami Vozdukha i ee Vozmozhnye Meteorologicheskie Primeneniia. B. V. Deriagin and O. M. Todes. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady),* Vol. 62, No. 1, September 1, 1948, pp. 93–96, illus. 2 references. (In Russian.) Theory of the motion of droplets in an ascending current of unsaturated or supersaturated air and its possible meteorological applications.

Essai d'Étude Statistique des Sources d'Atmosphériques en Europe et sur l'Atlantique Nord. P. Doury. *Journal Scientifique de la Météorologie,* Vol. 2, No. 6, April–June, 1950, pp. 56–58, illus. 2 references. The regular plotting of atmospheric centers shows the existence of general seasonal characteristics that affect their frequency and distribution.

Quelques Considérations sur les Trajectoires et les Lignes de Courant. A. Rouaud. *Journal Scientifique de la Météorologie,* Vol. 2, No. 6, April–June, 1950, pp. 33–49, illus. 3 references. Method of calculating the path of a mobile circular cyclone moving with uniform velocity.

The Weather and Climate of Korea. David M. Ludlum. *Weatherwise,* Vol. 3, No. 4, August, 1950, pp. 80–82, illus.

Meteoric Echo Study of Upper Atmosphere Winds. L. A. Manning, O. G. Villard, Jr., and A. M. Peterson. *Institute of Radio Engineers, Proceedings,* Vol. 38, No. 8, August, pp. 877–883, illus. 12 references.

Navigation (29)

Air Traffic Control; An Examination of Present Day Problems. The Controller's Viewpoint. M. A. Young. **The Requirement for Precise Navigation.** G. E. Bell. **Preventive Navigation.** D. Barnett. *Institute of Navigation, Journal,* Vol. 3, No. 3, July, 1950, pp. 211–250, illus. 1 reference.

Microwave Direction Finding for Aircraft Navigation. V. D. Burgmann and K. V. Sheridan. *Institute of Navigation, Journal,* Vol. 3, No. 3, July, 1950, pp. 251–269, illus. 8 references.

Photography (26)

Contributions to the Theory and Mechanics of Photo-Interpretation from Vertical and Oblique Photographs. Amrom H. Katz. *Photogrammetric Engineering,* Vol. 16, No. 3, June, 1950, pp. 339–386, illus. 8 references.

Application of Color Photography. Cullen E. Waldo. *Photogrammetric Engineering,* Vol. 16, No. 3, June, 1950, pp. 327, 328.

Aerial Photo Volume Tables. Robert B. Pope. *Photogrammetric Engineering,* Vol. 16, No. 3, June, 1950, pp. 325–327.

Scales of Oblique Photographs. Benjamin B. Lane, Jr. *Photogrammetric Engineering,* Vol. 16, No. 3, June, 1950, pp. 409–414, illus.

Use of Photos by the Forest Survey in California. K. E. Bradshaw. *Photogrammetric Engineering,* Vol. 16, No. 3, June, 1950, pp. 315–317.

The Use of Aerial Photographs in Timber Cruising on the National Forests. Homer J. Hixon. *Photogrammetric Engineering,* Vol. 16, No. 3, June, 1950, pp. 317–321.

Use of Aerial Photographs in the Inventory Phase of the Forest Management Job. H. K. Trobitz. *Photogrammetric Engineering,* Vol. 16, No. 3, June, 1950, pp. 321–324.

The Use of Aerial Photographs in Range Inventory Work on the National Forests. John G. Clouston. *Photogrammetric Engineering,* Vol. 16, No. 3, June, 1950, pp. 329–331.

Use of Airphotographs in Land Appraisal Work in British Columbia. Ian Mahood. *Photogrammetric Engineering,* Vol. 16, No. 3, June, 1950, pp. 332, 333.

The Use of Aerial Photography in Oregon's Rehabilitation Program. R. M. Kallander. *Photogrammetric Engineering,* Vol. 16, No. 3, June, 1950, pp. 334, 335.

Drainage Pattern Significance in Airphoto Identification of Soils and Bedrocks. Merle Parvis. *Photogrammetric Engineering,* Vol. 16, No. 3, June, 1950, pp. 387–409, illus. 26 references.

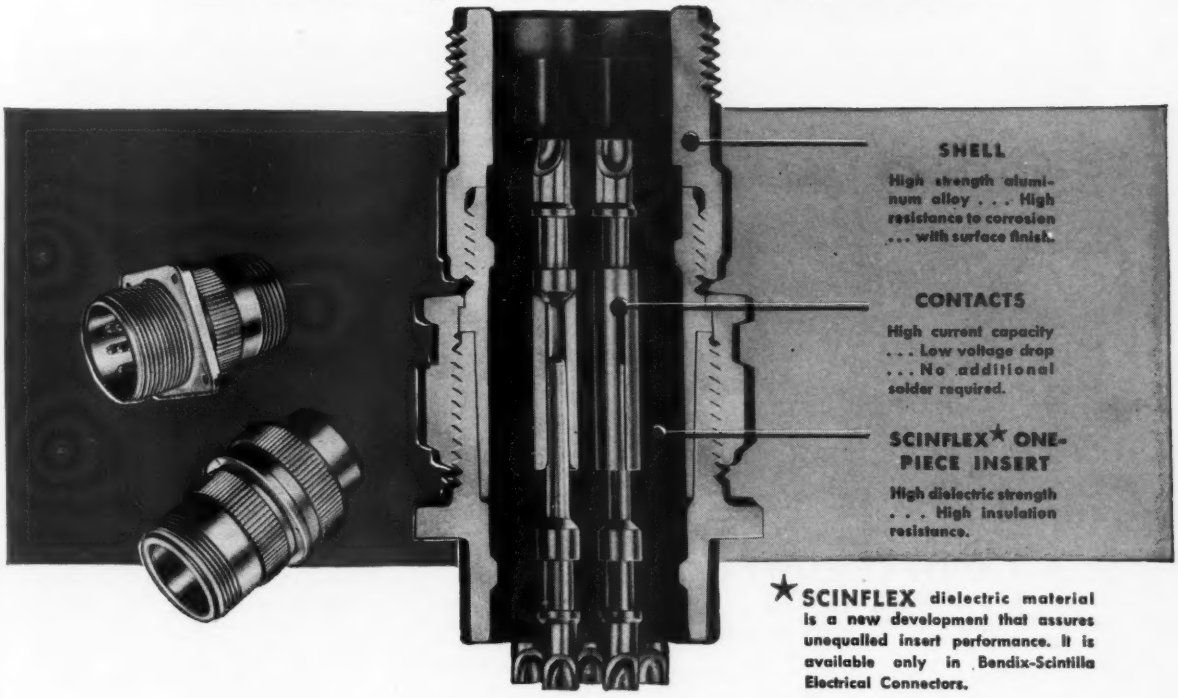
Aerial Photographic Interpretation of Urban Land Use in Madison, Wisconsin. L. L. Pownall. *Photogrammetric Engineering,* Vol. 16, No. 3, June, 1950, pp. 414–426, illus.

Panel Discussion: The Use of Aerial Photographs for Geologic Mapping. William S. Benninghoff, Robert S. Sigafoos, and Page Truesdell. *Photogrammetric Engineering,* Vol. 16, No. 3, June, 1950, pp. 428–433, illus.

ONLY BENDIX-SCINTILLA

ELECTRICAL CONNECTORS offer you this

IMPORTANT, EXCLUSIVE FEATURE . . .


SHELL
High strength aluminum alloy . . . High resistance to corrosion . . . with surface finish.
CONTACTS
High current capacity . . . Low voltage drop . . . No additional solder required.
SCINFLEX★ ONE-PIECE INSERT
High dielectric strength . . . High insulation resistance.

★**SCINFLEX** dielectric material is a new development that assures unequalled insert performance. It is available only in Bendix-Scintilla Electrical Connectors.

. . . PRESSURE TIGHT SOCKET CONTACT ARRANGEMENTS!

Outstanding design and fine workmanship, combined with materials that will meet every requirement, make possible our "pressurized" connectors that include both pin and socket arrangements for ALL sizes of contacts.

PLUS ALL THESE OTHER FEATURES

- Moisture-proof
- Radio Quiet
- Single-piece Inserts
- Vibration-proof
- Light Weight
- High Insulation Resistance
- Easy Assembly and Disassembly
- Fewer Parts than any other Connector
- No additional solder required

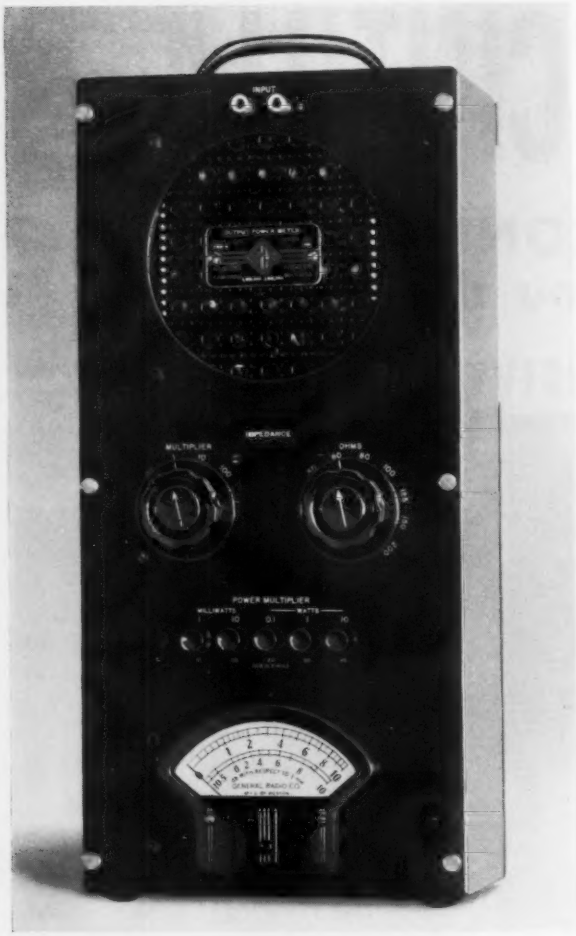
Write our Sales Department for detailed information.

BENDIX SCINTILLA

SCINTILLA MAGNETO DIVISION OF
SIDNEY, NEW YORK

Bendix AVIATION CORPORATION

FACTORY BRANCH OFFICES



A-F OUTPUT POWER MEASUREMENTS
from 0.2 mw to 100 Watts

This direct-reading meter is invaluable for measurements of the power output of audio-frequency circuits. Essentially it is equivalent to an adjustable load impedance across which is connected a voltmeter calibrated directly in watts dissipated in the load. Its features include:

VERY WIDE RANGES

POWER: 0.2 milliwatt to 100 watts
IMPEDANCE: 2.5 to 20,000 ohms

GOOD ACCURACIES

IMPEDANCE: within ± 2%, except at higher audio frequencies where error for higher impedance settings may be greater. At 15,000 cycles, input impedance error is about 5% for impedances from 10,000 to 20,000 ohms

POWER: Over-all frequency characteristic of power indication is flat within ± 0.5 db from 20 to 10,000 cycles; within ± 0.75 db to 15,000 cycles

Waveform errors will depend upon the magnitude and phase of the harmonics present; these errors will not be serious with waveforms normally encountered in communication-frequency circuits.

TYPE 783-A OUTPUT-POWER METER . . . $310.00

GENERAL RADIO COMPANY
CAMBRIDGE 39, MASSACHUSETTS
NEW YORK CHICAGO LOS ANGELES

Present State of the Application of Photogrammetry to Cartography in Spain. Angel G. de Mendosa. *Photogrammetric Engineering*, Vol. 16, No. 3, June, 1950, pp. 433–437.

Specifications for Aerial Photography and Mapping by Photogrammetric Methods for Highway Engineering Purposes. William T. Pryor. *Photogrammetric Engineering*, Vol. 16, No. 3, June, 1950, pp. 439–444.

Record of the Panel Discussion on Specifications for Aerial Photography and Mapping by Photogrammetric Methods for Highway Engineering Purposes. *Photogrammetric Engineering*, Vol. 16, No. 3, pp. 445–474, June, 1950.

Power Plants

The Gyroscopic Effect of a Rigid Rotating Propeller on Engine and Wing Vibration Modes. R. H. Scanlan and John C. Truman. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 653–659, 666, illus. 5 references.

JET & TURBINE (5)

Gas Turbine Combustion Efficiency Calculations. J. G. Withers. *Aircraft Engineering*, Vol. 22, No. 258, August, 1950, pp. 218–222, illus. 3 references.

A critical examination of the principles involved in the determination of combustion efficiency which clarifies the various definitions that have been employed and permits a standard method of calculation to be developed. This method, although simple, is applicable to the full range of gas-turbine operating conditions and fuels. The empirical expressions that are obtained enable the enthalpies of the reactants and of the products of combustion to be calculated to an adequate standard of accuracy. Difference in calculated efficiencies obtained from alternate definitions are determined under extreme conditions; errors in combustion efficiency determination, which occur when using the heat balance, and gas analysis techniques are examined.

Effect of Heat and Power Extraction on Turbojet-Engine Performance. II—Effect of Compressor-Outlet Air Bleed for Specific Modes of Engine Operation. Frank E. Rom and Stanley L. Koutz. *U.S., N.A.C.A., Technical Note No. 2166*, August, 1950. 18 pp., illus. 2 references.

Tables of Thermodynamic Functions for Analysis of Aircraft-Propulsion Systems. Vearl N. Huff and Sanford Gordon. *U.S., N.A.C.A., Technical Note No. 2161*, August, 1950. 99 pp., illus. 38 references.

Some Remarks on A. N. Tifford's Paper: "Propulsive Efficiency of Modern Aircraft Power Plants." M. Z. v. Krzywoblocki and R. W. McCloy. **Author's Reply.** *Ohio State University, Columbus, Engineering Experiment Station, Bulletin*, Vol. 22, No. 3, June, 1950, pp. 30–32. 9 references.

Transport Best Bet: Axial-Flow Jets. Winnett Boyd. *Aviation Week*, Vol. 52, No. 20, May 15, 1950, pp. 23, 24, 26–28, 31, 32, 35, 36, illus.

The willingness of the public to pay premium fares for high-speed, safe, comfortable transportation and current trends in operational and maintenance efficiency indicate that by 1956 jet-turbine aircraft will be a dominant factor in air transport in the 500-m.p.h. range.

Sportflugzeug mit Dusentrieb? *Schweizer Aero-Revue*, Vol. 25, No. 1, January, 1950, pp. 36, 37, illus. A gas turbine for personal airplanes.

An Analysis of the Autorotative Performance of a Helicopter Powered by Rotor-Tip Jet Units. Alfred Gessow. *U.S., N.A.C.A., Technical Note No. 2154*, July, 1950. 27 pp., illus. 5 references.

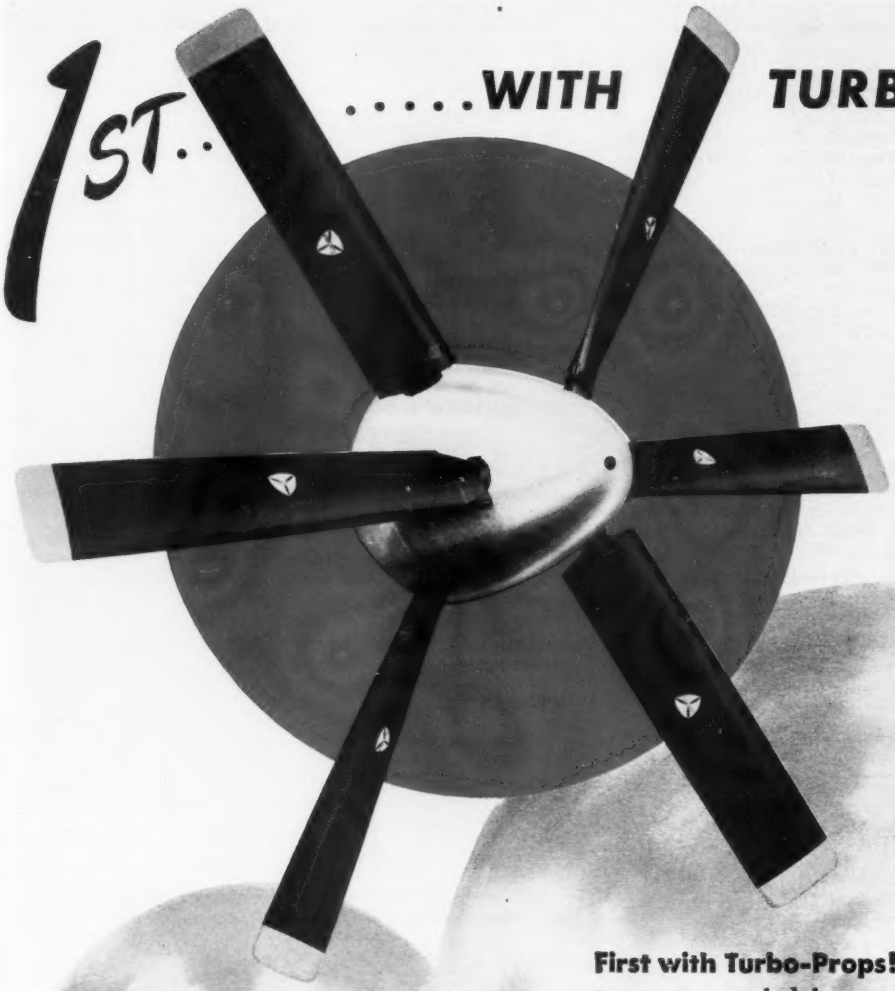
RECIPROCATING (6)

Enige Typische Breukgevallen bij Zuigers van Vliegtuigmotoren. G. Broersma. *De Ingenieur in Indonesië*, No. 1, 1950, pp. III.1–III.10, illus. 20 references. (Reprint.) Some typical cases of fracture in aircraft-engine pistons.

Production (36)

Producibility as Applied to Airframes. E. O. Baumgarten and A. C. Slatter. *Automotive Industries*, Vol. 1031, No. 4, August 15, 1950, pp. 34, 35, 60, 62, illus. A discussion of types of joints in air-frame construction and of the problems encountered in mating parts, components, and assemblies.

1ST.. .....WITH TURBO-PROPS



AEROPRODUCTS
TURBO-PROP INSTALLATIONS

CONVAIR XP5Y
DOUGLAS XA2D
ALLISON TURBOLINER
OTHERS UNANNOUNCED

First with Turbo-Props! Propulsive horsepower unequaled by any other propeller in use today is delivered by this dual rotation Aeroprop, which is being powered by ALLISON, NORTHROP and other turbines soon to be announced. Single rotation Aeroprops are also available for turbines or reciprocating engines.

ALSO USING AEROPROPS
NAA-T28, F82 ... Douglas-AD ... Grumman-F8F

"SOON---SUPERSONICS"

Aeroproducts

BUILDING for today
DESIGNING for tomorrow

AEROPRODUCTS DIVISION • GENERAL MOTORS CORPORATION • DAYTON, OHIO

Production Engineering, Administration and Management. III. J. V. Connolly. *Aircraft Engineering*, Vol. 22, No. 258, August, 1950, pp. 240–243, illus. 16 references. The importance of statistical analysis and the part played by machine-tool operation in production.

Airspeed Ambassador. II—Forming Reflexed Components on the Hufford Machine; Press-Brake Technique; Fuselage Structure, Frame-Subassemblies, Stringer-Drilling. S. C. Poulsen. *Aircraft Production*, Vol. 12, No. 142, August, 1950, pp. 241–247, cutaway drawings.

Bent Structural Members. I. R. M. Howarth. *Aircraft Production*, Vol. 12, No. 142, August, 1950, pp. 252–256, illus. 1 reference.

A qualitative analysis and a comparison of the results of bending by semiconcentrated loads and stretch-bending. Although products made by the two methods may be superficially alike, the extreme fiber strain is considerably higher when a given bend is produced by stretch-bending than when it is produced without stretching.

Curved Shaping; Machining a Bibby-Coupling Member for the Gipsy Queen Engine. *Aircraft Production*, Vol. 12, No. 142, August, 1950, pp. 237–240, illus.

Nickel-Alloy Sheet; Some Notes on Spinning, Drawing, Shearing and Perforating Monel, Nickel and Inconel. *Aircraft Production*, Vol. 12, No. 142, August, 1950, pp. 257–259, illus.

Slotted Angle; An Adaptable Material for the Construction of a Wide Range of Structures. *Aircraft Production*, Vol. 12, No. 142, August, 1950, p. 249, illus.

Designing Low-Cost Forgings. J. J. Sloan and K. R. Denny. *Machine Design*, Vol. 22, No. 8, August, 1950, pp. 154–156, illus. The design of dies to ensure optimum strength characteristics and to reduce the cost of die forgings.

Turbine-Blade Polishing; An Automatic Process Developed by A. V. Roe Canada, Ltd. *Aircraft Production*, Vol. 12, No. 142, August, 1950, pp. 248, 249, illus.

Propellers (11)

Axial-Momentum Theory for Propellers in Compressible Flow. Arthur W. Vogeley. *U.S., N.A.C.A., Technical Note No. 2164*, August, 1950. 14 pp., illus. 4 references.

Rotating Wing Aircraft (34)

An Analysis of the Autorotative Performance of a Helicopter Powered by Rotor-Tip Jet Units. Alfred Gessow. *U.S., N.A.C.A., Technical Note No. 2154*, July, 1950. 27 pp., illus. 5 references.

Discussion of L. S. Wigdortchik's "Economics of the Helicopter—Present and Future." J. Shapiro. *American Helicopter*, Vol. 19, No. 8, July, 1950, pp. 13–16, 19, 20, illus.

Proving Pulse-Jets for Helicopters (American Helicopter XX-5). *The Aeroplane*, Vol. 79, No. 2043, August 4, 1950, pp. 136, 137, illus.

Development of the McDonnell XHJD-1. M. Berry. *American Helicopter*, Vol. 19, No. 8, July, 1950, pp. 6–9, 18, illus.

Low-Priced 2-Pl. Helicopter (Seibel S-4). Robert N. Elliott, Jr. *Southern Flight*, Vol. 34, No. 2, August, 1950, pp. 20, 21, illus.

Sciences, General (33)

MATHEMATICS

Method of Characteristics for the Solution of Nonlinear Partial Differential Equations. R. Courant and P. Lax. (*Symposium on Theoretical Compressible Flow*, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1132*, July 1, 1950, pp. 61–71. 8 references.

A classification of quasilinear first-order partial differential equations for n functions of two independent variables and a detailed discussion of totally hyperbolic systems.

Stability of Solution of Partial Differential Equations. L. H. Thomas. (*Symposium on Theoretical Compressible Flow*, June 28, 1949.) *U.S., Naval Ordnance Laboratory, Report No. 1132*, July 1, 1950, pp. 83–94, illus.

Struktura D-Razbieniia Prostranstva Polinomov i Diagrammy Vyshnegradskogo i Naikvista. IU. I. Neimark. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 60, No. 9, June 21, 1948, pp. 1503–1506, illus. 6 references. (In Russian.) The structure of D-decomposition of a polynomial space and Vyshnegradskii and Nyquist diagrams.

Struktura D-Razbieniia Prostranstva Polinomov i Diagrammy Vyshnegradskogo i Naikvista. IU. I. Neimark. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 49, No. 5, February 11, 1948, pp. 853–856. 11 references. (In Russian.) The structure of D-decomposition of a polynomial space and Vyshnegradskii and Nyquist diagrams.

Priblizhennoe Reshenie Obyknovennykh Differentsial'nykh Uravnenii Liubogo Poriadka Metodom Posledovatel'nykh Priblizhenii na Osnove Teoremy S. A. Chaplygina o Differentsial'nykh Neravenstvakh. B. N. Babkin. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 49, No. 3, January 21, 1948, pp. 419–422. 3 references. (In Russian.) Approximate solution of ordinary differential equations of any order by the method of successive approximations on the basis of S. A. Chaplygin's theorem of differential equations.

O Funktsiiakh Grina Obyknovennykh Kvazi-Differentsial'nykh Uravnenii. P. Kalafati. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 49, No. 3, January 21, 1948, pp. 427–430. 1 reference. (In Russian.) On Green's functions of ordinary quasidifferential equations.

K Teoreme D. F. Egorova ob Izmerimykh Funktsiiakh. P. B. Frumkin. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 60, No. 6, May 21, 1948, pp. 973–975. 3 references. (In Russian.) D. F. Egorov's theorem of measurable functions.

MECHANICS

O Sushchestvovanii Elektromekhanicheskikh Analogii. G. A Gamburtsev. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 60, No. 8, June 11, 1948, pp. 1335–1337, illus. 4 references. (In Russian.) On the nature of electromechanical analogies.

MECHANICS—VIBRATION

The Gyroscopic Effect of a Rigid Rotating Propeller on Engine and Wing Vibration Modes. R. H. Scanlan and John C. Truman. *Journal of the Aeronautical Sciences*. Vol. 17, No. 10, October, 1950, pp. 653–659, 666, illus. 5 references.

Space Travel

Initial Objectives in Astronautics. Kenneth W. Gatland, Alan E. Dixon, and Anthony M. Kunesch. *British Interplanetary Society, Journal*, Vol. 9, No. 4, July, 1950, pp. 155–178, illus. 15 references.

A survey of German rocket research projects and orbital rocket and earth-satellite vehicle programs (Project Rand); and an evaluation of proposed designs for extraterrestrial rockets.

Minimal Trajectories. Derek F. Lawden. *British Interplanetary Society, Journal*, Vol. 9, No. 4, July, 1950, pp. 179–186, illus. 2 references.

A calculation of the most economical manner in which to program the fuel consumption and direct thrust of a rocket so that it will describe a trajectory joining two given points, with its velocity at these points being prescribed. The special case of no gravitational field is also considered.

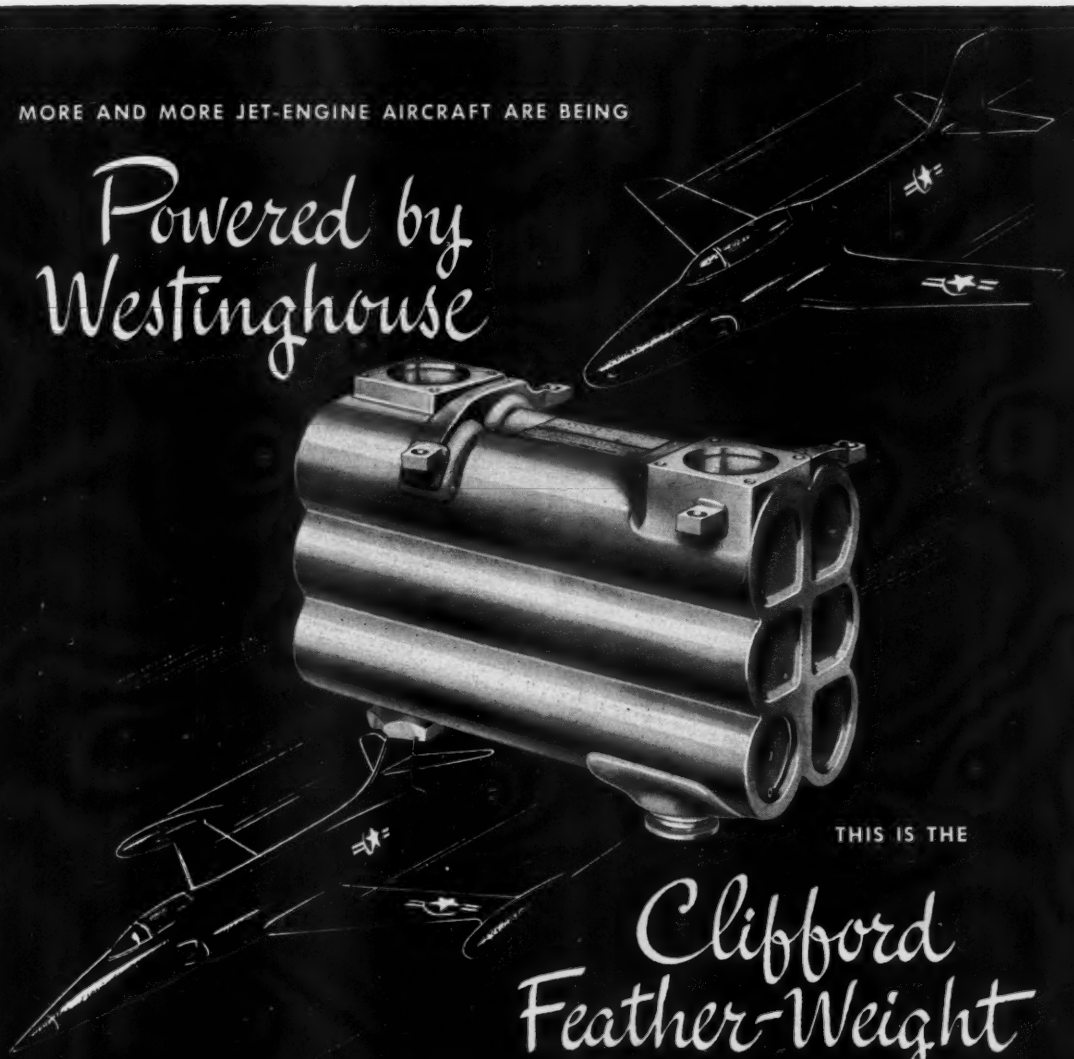
Structures (7)

Flutter. E. P. Grossman. Translation from the Russian Prepared by Brown University. *U.S., Air Force, Technical Report No. F-TS-1225-IA (GDAM A9-T-44)*, May, 1949. 393 pp., illus.

A comprehensive study of aeroelasticity intended to be used as a textbook on flutter for advanced students of aerodynamics. The entire work is based on the assumption of steady motion and emphasizes the aspects of theory which are applicable in aircraft design and construction or are required to clarify the physical nature of the phenomenon. The first three chapters deal in general with the theory of free oscillations as it applies to flutter in an air stream. The subsequent chapters explain in detail the methods of calculation used in flutter analysis, the effect of struc-

MORE AND MORE JET-ENGINE AIRCRAFT ARE BEING

Powered by Westinghouse



THIS IS THE

Clifford Feather-Weight

THAT COOLS THE OIL IN MANY WESTINGHOUSE JET ENGINES

More and more of the best in modern aircraft . . . jet-propelled and conventional . . . depend on the superior performance of Clifford All-Aluminum Feather-Weights . . . *the only all-brazed type of oil cooler.* Clifford's *patented* brazing process and Clifford's *unique* wind-tunnel laboratory contribute to Feather-Weight superiority. Your inquiry is invited. CLIFFORD MANUFACTURING COMPANY, 138 Grove Street, Waltham 54, Massachusetts. Division of Standard-Thomson Corporation. Sales offices in New York, Detroit, Chicago, Los Angeles.

CLIFFORD

HYDRON Metal Bellows

ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES

HYDRAULICALLY-FORMED BELLOWS AND BELLOWS ASSEMBLIES

tural parameters upon the critical velocity, and the influence of control surfaces upon the flutter characteristics of an aircraft. Throughout, special attention has been paid to design procedures, to the selection of optimum structural parameters, and to practical measures for preventing flutter.

Vibration in Composite Beams. M. Z. Krzywoblocki. *Aircraft Engineering*, Vol. 22, No. 258, August, 1950, p. 223. 6 references.

The equations for the natural frequency of an elastic beam, derived on the basis of Rayleigh's principle and the Ritz method, are extended to the case of free vibration of a set of two elastic beams, rigidly connected, with a number of concentrated loads elastically suspended.

The Gyroscopic Effect of a Rigid Rotating Propeller on Engine and Wing Vibration Modes. R. H. Scanlan and John C. Truman. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 653–659, 666, illus. 5 references.

Readers' Forum: Effect of Wing Parameters on Load Intensity in Wing Skin. B. E. Gatewood. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 668, 669, illus.

An Initial Approach to the Overall Structural Problems of Swept Wings Under Static Loads. E. E. Sechler, M. L. Williams, and Y. C. Fung. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 639–646, illus. 6 references.

The Prediction of the Strength of a "Standard" Component from Tests Made on a "Typical Element." N. B. Joyce. *Australia, Department of Supply, Aeronautical Research Laboratories, Report No. SM. 155*, June, 1950. 26 pp., illus.

A general method for the correction of test data obtained from a single typical aircraft component by which a prediction of allowable design values of the strength of the component may be obtained. Approximate corrections are found for the variables introduced by the allowable tolerances on sheet thickness and Young's modulus and by variations in column length and in material properties. Each correction is a factor by which the measured test value should be multiplied. These multiplying factors are plotted for convenient use.

Circular Plates of Non-Uniform Thickness. W. Gittleman. *Aircraft Engineering*, Vol. 22, No. 258, August, 1950, pp. 224–227, illus. 2 references.

The plate, subjected to symmetrical lateral loading, is divided into concentric rings of uniform thickness, and expressions of the changes in the sum and difference of the radial and tangential stresses that occur in proceeding across a ring and at the interface between two adjacent rings are successively applied. Two trial solutions are necessary from which the "correct" approximate solution is deduced by using the equations connecting the sum of the stresses at the center or the inner rim with the sum or differences of the stresses at the outer rim.

Opredelenie Napriazhenii v Plastinke s Neskol'kimi Zapressovannymi v Nee Kruglymi Shaibami. N. D. Tarabasov. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 63, No. 1, November 1, 1948, pp. 15–18, illus. 3 references.

Determination of the stresses in a thin circular plate with circular holes into which circular discs, of the same thickness as the plate, have been pressed with a given tightness. The materials of the plate and the discs are assumed to be elastic, isotropic, and homogenous and possess identical mechanical properties.

Difraktsiia Ploskoi Uprugoi Volny Otnositel'no Polubezkonechnoi Priamolineinoi Zheskto Zakreplennoi Shcheli. M. M. Fridman. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 60, No. 7, June 1, 1948, pp. 1145–1148. 2 references. (In Russian.) Diffraction of a plane elastic wave along a surface with respect to a semi-infinite rectilinear slit, whose edges are assumed to be rigidly fixed.

Finite Elastic Deformation of Incompressible Isotropic Bodies. A. E. Green and R. T. Shield. *Royal Society (London), Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 202, No. 1070, August 7, 1950, pp. 407–419. 9 references.

The theory of finite elastic deformation of incompressible isotropic bodies is expressed in a simple form in tensor notation, using a general system of coordinates that move with the body as it is deformed. The advantages of the present methods are illustrated by an examination of a problem solved by Rivlin and by

BESTOS VELBESTOS VELBES

GASKETS

are important in an aircraft engine.
Our VELBESTOS 170-1 conforms to
A M S Specification 3232E.

May we send samples for experimental purposes?

THE VELLUMOID COMPANY
WORCESTER 6, MASS.

MPB makes more than 50 types and sizes of miniature ball bearings

BEARINGS, Ball, miniature. Standard and Special for application in precision mechanisms to minimize friction and wear. High load capacity in minimum space. Light in weight. Specify MPB for shock loads, continuous operation, extreme temperature ranges and delicate responsiveness. Special designs and complete engineering service for your application. Write for catalog AE

MPB MINIATURE *Precision* BEARINGS
INCORPORATED
KEENE, NEW HAMPSHIRE, U.S.A.

Engineers wanted for

MILITARY PROJECTS

at North American Aviation, Inc.
Los Angeles

Excellent openings for qualified

AERODYNAMICISTS
(Design and Research)

STRESS ANALYSTS

AIRCRAFT DESIGNERS
(Electrical, Electro-Mechanical, Structural, Hydraulic, Etc.)

and specialists in all other phases of aircraft engineering. Please include summary of experience in reply.

Engineering Personnel Office
Section 2

NORTH AMERICAN AVIATION, INC.
LOS ANGELES INTERNATIONAL AIRPORT
LOS ANGELES 45, CALIF.

High Tension
Low Tension
High Frequency

LET BENDIX-SCINTILLA EXPERIENCE HELP YOU DETERMINE THE BEST TYPE OF IGNITION EQUIPMENT FOR EVERY OPERATING CONDITION!

In the past twenty-five years Bendix-Scintilla has solved ignition problems for practically every type of aircraft engine and operating condition. Out of this wealth of specialized experience has come one unchallenged fact—*No single type of ignition equipment* is *the final* solution to every *operating problem*. That is why Bendix-Scintilla approaches each new assignment with an open mind. That is why you can count on Bendix-Scintilla recommending the type of ignition equipment best fitted for your specific purpose. And *backing up its recommendation* with an experience-proven product unexcelled for efficiency and long life.

BENDIX SCINTILLA

SCINTILLA MAGNETO DIVISION OF
SIDNEY, NEW YORK

Bendix AVIATION CORPORATION

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N. Y.

FACTORY BRANCH OFFICES:
117 E. Providencia Avenue, Burbank, California • 23235 Woodward Avenue, Ferndale, Michigan • 7829 W. Greenfield Avenue, West Allis 14, Wisconsin.

the solution of the problem of a rotating cylinder and of a uniform spherical shell under symmetric internal and external pressures using a completely general form of the strain-energy function.

Finite Strains in an Anisotropic Elastic Continuum. J. G. Oldroyd. *Royal Society (London), Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 202, No. 1070, August 7, 1950, pp. 345–358. 5 references.

The invariance properties required of the equations of state of a homogeneous continuum, in the case of an elastic solid deformed from an unstressed equilibrium configuration, is extended by taking into account thermodynamic restrictions on the form of the equations. The general form of the finite strain-stress-temperature relations, which are expressed in terms of a free-energy function, is deduced without assuming that the material is isotropic. The equations of state are obtained by considering quasi-static changes in an elastic solid continuum, and a compatibility condition for the finite strains at different points of a continuum is derived. The derivation and use of equations of state involving anisotropic physical constants is illustrated in the torsion of an anisotropic cylinder.

Readers' Forum: The Basic Theorems in the Plastic Theory of Structures. P. S. Symonds. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 669, 670. 6 references.

Uprugo-Plasticheskoe Sostoianie pod Sosredotochennoi Siloi, Prilozhennoi k Poluplokosti. K. P. Shevchenko. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 61, No. 1, July 1, 1948, pp. 29, 30, illus. (In Russian.) The elasto-plastic condition under a concentrated force applied to a semi-surface.

Ploskie Volny i Volny Releia v Anizotropnoi Srede. V. A. Sveklo. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 49, No. 5, February 11, 1948, pp. 871–874. (In Russian.)

Plane waves and Rayleigh waves in an anisotropic medium as investigated by the Sobolev-Smirnov method. This method uses the so-called functional-invariant solutions of the wave equation—that is, it employs those solutions whose arbitrary function is also a solution of the wave equation.

Teoriia Uprugosti pri Bol'shikh Deformatsiiakh, Prevoskhodiashchikh Predel Proportional'nosti. P. M. Riz. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 49, No. 2, January 11, 1948, pp. 223–225. 4 references. (In Russian.) Theory of elasticity of large deformations exceeding the proportional limit.

Rasprostranenie Tsilindricheskikh Voln Sdviga v Uprugo-Viazko-Plasticheskoi Srede. V. V. Sokolovskii. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 60, No. 8, June 11, 1948, pp. 1325–1328, illus. (In Russian.) The axially symmetric problem of the propagation of cylindrical displacement waves in a medium having elastic and viscoplastic properties.

Istochniki Kolebanii v Anizotropnoi Poluplokosti. V. A. Sveklo. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 49, No. 6, February 21, 1948, pp. 1077–1080. 1 reference. (In Russian.) Sources of vibrations in an anisotropic semisurface.

Ob Odnom Metode v Teorii Uprugikh i Plasticheskikh Deformatsii. I. I. Gol'denblat. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 61, No. 6, August 21, 1948, pp. 1001–1004. 1 reference. (In Russian.) A method in the theory of elastic and plastic deformations.

Ob Odnoi Forme Predstavleniia Komponent Napriazheniia v Teorii Plastichnosti. V. V. Sokolovskii. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 61, No. 2, July 11, 1948, pp. 223–225. 1 reference. (In Russian.) On one form of stress component representation in the theory of elasticity.

Readers' Forum: Note on Plastic Column Behavior. George Gerard. *Journal of the Aeronautical Sciences*, Vol. 17, No. 10, October, 1950, pp. 670, 671.

Critical Stress of Plate Columns. John C. Houbolt and Elbridge Z. Stowell. *U.S., N.A.C.A., Technical Note No. 2163*, August, 1950. 16 pp., illus. 3 references.

Prodol'no-Poperechnyi Izgib Balki na Uprugom Osnovanii. SH. E. Mikeladze. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 49, No. 3, January 21, 1948, pp. 451–454. 5 references. (In Russian.) Longitudinal and cross-sectional bending of a beam on an elastic foundation.

Udar Tsilindra o Poverkhnost Sredy, Mekhanicheskie Svoistva Kotoroi Meniaiutsia vo Vremeni. M. I. Rozovskii. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 61, No. 1, July 1, 1948, pp. 25–28. 3 references. (In Russian.) The impact of a cylinder against the surface of a medium whose mechanical properties vary with time.

Ob Odnom Metode Resheniia Granichnykh Zadach Sinusoidal'nykh Kolebanii Uprugovo Tsilindra. I. N. Vekua. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 60, No. 5, May 11, 1948, pp. 779–782. 7 references. (In Russian.) A method of solving the boundary problems of the sinusoidal oscillations of an elastic cylinder.

Raspnostranenie Uprugo-Viazko-Plasticheskikh Voln v Sterzhniakh. V. V. Sokolovskii. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 60, No. 5, May 11, 1948, pp. 775–778. (In Russian.) Propagation of waves in bars having elastic and viscoplastic properties.

K Zadache ob Uprygom Ravnovecii Beskonechnoi Polocy. S. E. Birman. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 62, No. 2, September 11, 1948, pp. 187–190. 3 references. The problem of the elastic equilibrium of an infinite bar.

K Zadacham o Tonkostennykh Sterzhniakh. S. E. Birman. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 62, No. 3, September 31, 1948, pp. 305–308, illus. 1 reference. (In Russian.) Problems of thin-walled hollow rods of square cross section.

Napriazhenia i Deformatsii v Tsilindricheskoi Obolochke s Zhestkim Poperechnymi Secheniiami. R. A. Adadurov. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 62, No. 2, September 11, 1948, pp. 183–186. 1 reference. (In Russian.) Strains and deformations in a cylindrical envelope with rigid cross sections.

Thermodynamics (18)

Tables of Thermodynamic Functions for Analysis of Aircraft-Propulsion Systems. Vearl N. Huff and Sanford Gordon. *U.S., N.A.C.A., Technical Note No. 2161*, August, 1950. 99 pp., illus. 38 references.

Effect of Initial Mixture Temperature on Flame Speeds and Blow-Off Limits of Propane-Air Flames. Gordon L. Dugger. *U.S., N.A.C.A., Technical Note No. 2170*, August, 1950. 20 pp., illus. 16 references.

Decomposition in a Preheated Nitric Oxide Jet. Samuel Loshaek. *Wisconsin, University, Naval Research Laboratory, Department of Chemistry, Report No. CM-607*, May 27, 1950. 109 pp., illus. 33 references.

A stabilized nitric oxide decomposition flame was established when sufficiently high rates of flow of nitric oxide gas were used. The activation energy for the reaction was determined from the rate of decomposition of the reaction. Since this activation energy increased with increasing temperature of the reaction zone, the decomposition mechanism is complex and may involve atomic reactions. This fact would account for the failure of the experiment to verify the Hirschfelder-Curtiss theory of flame propagation.

Laminar-Boundary-Layer Heat Transfer Characteristics of a Body of Revolution with a Pressure Gradient at Supersonic Speeds. William R. Wimbrow and Richard Scherrer. *U.S., N.A.C.A., Technical Note No. 2148*, August, 1950. 23 pp., illus. 8 references.

Obobshchennoe Integral'noe Sootnoshenie dlia Teplogo Pogranichnogo Sloia i ego Primenenie k Raschety Teploobmena. L. I. Kudriashev. *Akademiia Nauk S.S.S.R., Leningrad, Comptes Rendus (Doklady)*, Vol. 63, No. 1, November 1, 1948, pp. 23–25. 5 references. (In Russian.) A generalized integral correlation for the heated boundary layer and its application to the calculation of heat exchange.

Contributions to the Theory of Heat Transfer Through a Laminar Boundary Layer. M. J. Lighthill. *Royal Society (London), Proceedings, Series A, Mathematical and Physical Sciences*, Vol. 202, No. 1070, August 7, 1950, pp. 359–377, illus. 9 references.

An approximation to the heat-transfer rate across a laminar incompressible boundary layer for arbitrary distribution of mainstream velocity and of wall temperature is obtained by using the

(*Continued on page 89*)

the SPERRY A-12 Gyropilot*...

is Boeing's and the U. S. Air Force's choice for the B-47B Boeing *Stratojet*, because of its ability . . . already proved on the Boeing *Stratocruiser* . . . to provide smooth, precise *automatic* flying under all flight conditions.

- The Gyropilot does for the pilot of the B-47B . . . a military jet of 600-miles-per-hour speed and over 2000-mile cruising range . . . what it does for the pilot of the commercial airliner.

- It gives him complete automatically-stabilized control of his aircraft through all weather even at high speeds and high altitudes . . . enables him with the automatic approach control to make automatic approaches through low weather ceilings in rough air.

- Today, many leading airlines . . . in continuing efforts to improve schedule reliability and make service increasingly independent of weather . . . are using the Sperry A-12 Gyropilot to supplement their flight personnel's skill and experience.

*Trade Mark Reg. U. S. Pat. Off.

SPERRY GYROSCOPE COMPANY

DIVISION OF THE SPERRY CORPORATION, GREAT NECK, NEW YORK • CLEVELAND • NEW ORLEANS • NEW YORK • LOS ANGELES • SAN FRANCISCO • SEATTLE

Great Airlines All

...with one vital element in common!

Here grouped are the insignia of 16 leading U.S. airlines.

And linking these far-flung airlines, as well as 18 foreign airlines, is the fact that nearly all of the hundreds of planes they use daily are equipped with vital accessories designed and manufactured by AiResearch.

For AiResearch equipment is on every type of U.S. commercial transport manufactured during the past few years. Today we produce more types of air conditioning, pressurization and temperature control equipment for both military and commercial high speed, high altitude aircraft than any other concern in the world.

AiResearch is currently producing 560 aircraft assemblies, each designed to do a different job. These fall into eight basic categories: temperature controls, electric-electronic equipment, cabin superchargers, air cycle air conditioning, gas turbines, pneumatic power units, heat transfer equipment and cabin pressure controls.

We are proud to salute the great airlines of America who have shown their faith in these vital components precision engineered by AiResearch.

And we intend to continue to justify this faith by relentless pioneering in the field of high altitude, high speed flight.

AIRESEARCH MANUFACTURING COMPANY • LOS ANGELES 45, CALIFORNIA

AiResearch
DIVISION OF
THE GARRETT CORPORATION

Aeronautical Reviews — BOOKS

Scientific Research: Its Administration and Organization

Edited by George P. Bush and Lowell H. Hattery. Washington, American University Press, 1950. 190 pp. $3.25.

The management of research is still an art, but essentially a cooperative art. It also embraces significant elements of the social sciences, so differences of opinion and conflicts among the various schools of thought are bound to arise. However, because research has become big business and is of paramount importance in our lives, many people are striving to determine the optimum pattern for the organization and management of scientific research.

One of the best ways to approach the problem is to have competent people sit down and talk about the matter. In recent years there have been many symposia, conferences, and meetings on research management. They are probably all valuable, even though there is never complete concurrence among the contributors. They are doubly valuable when the proceedings are printed and made available to the public.

This book is that sort of a valuable contribution. It is adapted from the proceedings of the First Institute on Administration of Scientific Research and Development presented at Washington, D.C., by The American University with the cooperation of the National Research Council and the American Association for the Advancement of Science, which was held in June, 1949. There are 23 chapters grouped into six major divisions, as follows: Part One: Research Organization, Part Two: Administrative Process, Part Three: Research Personnel, Part Four: Aids to Research, Part Five: Research Product, and Part Six: Conclusion.

The contributors include representatives of the country's top-drawer scientists and research administrators; such names as L. R. Hafstad, H. L. Dryden, E. U. Condon, L. W. Bass, R. B. Stewart, M. H. Trytten, and H. A. Barton are among them.

The work has been unusually well organized for getting the most out of it, either by the straight-through reading technique or by bits-and-pieces study. The body of the work is well bracketed by Chapter 1 (by Prof. L. H. Hattery), which delineates the frame of reference for the study and by Chapter 23 (by Prof. G. P. Bush), which gives a concise and meaty summary of the findings and conclusions and which is an excellent guide for the detailed study of the main body of the book.

The frame of reference may best be summarized by quotations from Chapter 1. "There must be then a fine sensitivity for maintaining balance between the billion dollar annual program of research and development, and the careful nurture of individual initiative and talent, that the fertile imagination of science may soar to new heights of free creativeness. Herein lies the problem." There is no clean-cut, single-valued solution to this problem, as those who read this book will readily realize. However, the potentialities of solution are well outlined for those who read, and it can be a valuable book for those who are faced with the task of organizing and managing research. This volume is certainly one of the best contributions to the writings on the art and science of research management and is highly recommended to all those who are, or think they will be, involved in this important activity.

C. C. FURNAS
Director, Cornell Aeronautical Laboratory, Inc.

The Properties of Metallic Materials at Low Temperatures

By P. Litherland Teed. London, Chapman & Hall, Ltd.; New York, John Wiley & Sons, Inc., 1950. 222 pp., diagrs. $3.50.

This book is a compilation and summary of data taken from numerous technical publications regarding the effects of low temperatures on the mechanical properties of metals. Its publication is sponsored by the Council of the Royal Aeronautical Society.

The scope of the book may be judged by the following chapter headings:

(1) The change in mechanical properties of aluminum alloys with decrease in temperature.

(2) The change in yield, ultimate stress, elongation, and reduction of area of ferrous alloys with decrease in temperature, with some reference to reversibility. The change in elastic moduli and fatigue characteristics. Behavior of welds.

(3) The change in notched bar impact values of carbon steels with decrease in temperature. Some characteristics of welds.

(4) The change in notched bar impact values of alloy steels with decrease in temperature, with some reference to welds.

(5) The change in mechanical properties of magnesium alloys with decrease in temperature. The change in electrical resistance of copper. Difficulties with commutators arising from low temperature.

(6) The change in mechanical properties of copper alloys with decrease in temperature. The change in electrical resistance of copper. Difficulties with commutators arising from low temperature.

(7) The change in mechanical properties of nickel, zinc, tin, and lead and their alloys with decrease in temperature.

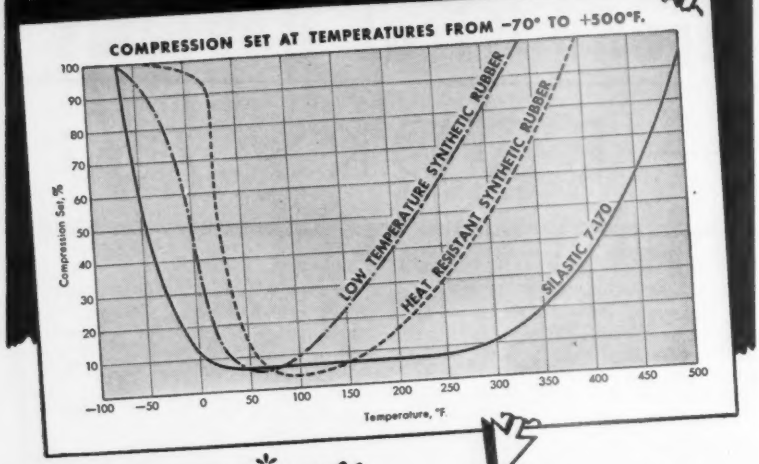
The text is used to introduce the tables, to comment on the results, and to draw such cautious conclusions as appear justified. The sources of the data are indicated by referring to a table of references at the end of each chapter. Where material properties are presented, the materials are also described as to composition as well as alloy type number. This is especially welcome in view of the fact that data are presented for American, English, and other alloys.

This book may be found useful not only as a source book but also as a critical commentary on the properties of metals at low temperature. The author impresses the reader with the complexity of the effect of low temperature upon the mechanical properties of metals and raises pertinent

For information on I.A.S. Library Service Facilities, see page 57

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

Where ordinary rubber gaskets fail . . .



SILASTIC* still stays Elastic!

AT EXTREME TEMPERATURES, Silastic has greater resistance to compression set—or to permanent deformation due to heat and pressure—than any other rubberlike material. Its elastic memory exceeds that of both the best low temperature and the best high temperature organic rubbers available. Silastic 7-170 forms a more resilient seal at −50°F. than a special low temperature organic rubber does at −7°F. At 450°F., Silastic has more resistance to permanent compression set than the most heat-stable organic rubbers have at 330°F.

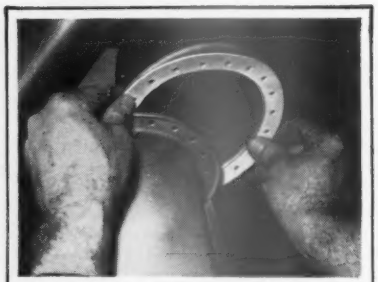
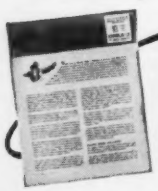


PHOTO COURTESY CONSOLIDATED VULTEE AIRCRAFT CORP.

In aircraft cabin heating and pressurizing systems, Silastic gaskets stay elastic under operating temperatures ranging from −70° to 400°F. Similarly, Silastic gaskets and O-rings withstand hot oils at about 450°F. in automotive, aircraft, diesel-electric engines.

Combine that kind of elastic memory with excellent resistance to aging, to oxidation and to attack by a variety of chemicals and hot oils, and you have Silastic—the most stable of all resilient gasketing materials. That's why design engineers and maintenance men specify Silastic, the Dow Corning Silicone rubber that pays for itself many times over in reduced maintenance costs and improved performance.

*T. M. REG. U. S. PAT. OFF.



SEND TODAY!

For your copy of Silastic Facts No. 10 containing new data on the properties, performances and applications for all Silastic stocks.

from +500°F. SILASTIC stays Elastic to −100°F.

DOW CORNING CORPORATION, DEPT. A-23, MIDLAND, MICH.
Please send me Silastic Facts No. 10
Name
Company
Address
City Zone State

Dow Corning
FIRST IN SILICONES

Atlanta • Chicago • Cleveland • Dallas • Los Angeles • New York • Washington, D. C.
In Canada: Fiberglas Canada Ltd., Toronto • In England: Albright and Wilson Ltd., London

questions regarding the interpretation of results obtained by the conventional test.

In view of the increasing demand for metals to operate at lower and lower temperatures, this book will undoubtedly find much use. The reviewer, who has on occasions found it necessary to search the literature for data of the type presented in this book, feels an appreciation for the commendable accomplishment by the author.

WILLIAM SCHROEDER
Research Engineer, Forming and Forging, Lockheed Aircraft Corporation

Book Notes

AERODYNAMICS

Tables of Supersonic Flow Around Cones of Large Yaw. Compiled under the direction of Zdeněk Kopal. (Massachusetts Institute of Technology, Department of Electrical Engineering, Center of Analysis, Technical Report No. 5.) Washington, U.S. Govt. Printing Office, 1949. 125 pp. $3.00.

These tables give, successively, the contributions u_2, v_2, w_2 to the velocity components u, v, w taken in the direction of increasing polar coordinates r, θ, ϕ due to the second-order effects of yaw, as functions of the angular variable θ, at 5°, 7.5°, 10°, 12.5°, 15°, 20°, and 25° and the corresponding proportional changes in pressure $p_0/\tilde{p}$, $p_2/\tilde{p}$ and density $\rho_0/\tilde{p}$ and $\rho_2/\tilde{p}$ due to the same cause. The velocity components are expressed in terms of the velocity c that the air in front of the shock wave would attain if allowed to expand adiabatically into a vacuum. Equations and formulas used in the computation of the tables are recapitulated in the introduction. Derivations and the analysis of the underlying hydrodynamical problem are contained in a forthcoming paper by Dr. Arthur H. Stone of the University of Manchester.

Mechanics of Flight. A. C. Kermode. 6th Ed. (An Introduction to Aeronautical Engineering, Vol. 1.) London, Sir Isaac Pitman & Sons, Ltd., 1950. 372 pp., illus., diagrs. 18*s*.

In this new edition of a book intended primarily for pilots and mechanics and last revised in 1945, the trend of recent editions toward writing for the pilot has been continued. New chapters on the elements of mechanics and high-speed flight have been added, and former material on propellers has been included in a new chapter on thrust. Jet and rocket propulsion are discussed in this and other chapters, particularly on range and endurance in the discussion of level flight. The number of numerical examples has been increased, and examples and the appendixes on airfoils and systems of units have been thoroughly revised.

AERONAUTICS, GENERAL

Proceedings, Seventh National Aviation Forum. Washington, National Aeronautic Association, December, 1949. 57 pp. Mimeographed.

Contents: Opening Address, Louis E. Leverone. A Tide in Men's Affairs, E. E. Wilson. Discussions by De Witt C. Ramsey, Kern Dodge, Bert C. Goss, R. F. Lybeck, William T. Piper, Albert F. Beitel, and Wayne Parrish. Cultural Aspects of Aviation, George D. Stoddard. Utilization Panel Discussion, J. J. O'Connell, Fred M. Glass, J. Carroll Cone, D. W. Rentzel, Joseph Garside, and James W. Austin. God and the Aeroplane, Maurice S. Sheehy.

AIR TRANSPORTATION

ANC Procedures for the Control of Air Traffic. 2nd Ed. (U.S. Navy, Air Force, Coast

Guard, Civil Aeronautics Administration.) Washington, U.S. Govt. Printing Office, 1950. 92 pp. $0.40.

This is an official manual standardizing procedures for air-traffic control and covering control of instrument flight rule traffic, airport traffic control, approach control, and procedures for alerting search and rescue facilities.

United States Overseas Air Cargo Services. N. W. Kendall. (U.S., Office of Domestic Commerce, Transportation Series No. 1.) Washington, U.S. Govt. Printing Office, 1950. 127 pp. $0.45.

This is a thorough survey of American foreign trade by air and air trade between the continental United States and noncontiguous territories, including descriptions of present services, the outlook for development of services and improvements needed, and problems requiring solution. Data are presented in 43 tables.

Modern Packaging Encyclopedia, 1950. New York, Packaging Catalog Corporation, 1949. 931 pp., illus. $5.00.

Following a section on packaging achievements in 19 different fields in case history form and a section on package planning, extensive sections are presented on materials of packaging, types of containers and boxes, machinery and equipment, shipping containers and equipment, and displays. The buyers' directory is extensive and is thoroughly cross-indexed, and the editorial content is also thoroughly indexed. Among the special topics covered are shipping regulations and packing for air shipment.

ATOMIC ENERGY

Atomic Physics. Wolfgang Finkelnburg. Translated from the revised German edition in cooperation with the author by George E. Brown. New York, McGraw-Hill Book Company, Inc., 1950. 498 pp., illus., diagrs. $6.50.

This translation is from *Einführung in die Atomphysik* (Berlin, 1948) and is essentially identical with the revised German edition now in preparation. The book is designed for upperclass and graduate students in physics, chemistry, and engineering, and for professional workers desiring to review the field. Emphasis is placed on a rigorous theoretical background and on the interrelations between such fields as atomic, molecular, nuclear, and solid-state physics, rather than mathematical derivations and details of experiments. The author is associated with the Engineer Research and Development Laboratories at Fort Belvoir, Va.

ELECTRONICS

Super-Regenerative Receivers. J. R. Whitehead. Cambridge, New York, Cambridge University Press, 1950. 169 pp., illus., diagrs. $4.75.

The author's purpose is to introduce the subject of superregenerative theory and design, including the operation of superregenerative circuits in the light of war experience, when they were widely used in pulse responders for radar identification of ships and aircraft. Introductory chapters outline the superregenerative principle, describing the linear and logarithmic modes of operation, automatic gain stabilization, and the build-up of oscillations in a vacuum-tube oscillator. The greater part of the book is concerned with the basic linear mode, proceeding through the general theory of superregenerative reception of a signal, reception and detection of a signal, and noise. Sinusoidal and other particular kinds of quench are discussed, then the logarithmic mode, automatic gain stabilization, and superregenerative circuits. Design data, symbols, and a short bibliography are included in appendixes. The author is Principal Scientific Officer of the Telecommunications Research Establishment.

Principles of Electric and Magnetic Circuits. Warren B. Boast. New York, Harper & Brothers, 1950. 367 pp., illus., diagrs. $4.75.

This textbook is intended for use in an introductory course of one semester in electrical engineering, with emphasis on electric and magnetic circuits. The first two parts cover basic concepts. Electromagnetic induction is discussed in Part 3, and the methods of electric network analysis in Part 4. Supplementary aspects of the subject are taken up in the final part, including conduction circuits with irregular boundaries, capacitance as a circuit element, and general circuit equations of resistance-capacitance-inductance systems. The author is a professor of electrical engineering at Iowa State College.

Recent Advances in Radio Receivers. L. A. Moxon. Cambridge, New York, Cambridge University Press, 1949. 183 pp., diagrs. $4.00.

The purpose of this book is to present recent advances in receiver design, with emphasis on the short-wave end of the spectrum and the accompanying requirements of high fidelity and low internal noise level. The reader is assumed to be familiar with prewar receiver design, as of about 1938. The final chapters (72 pages) deal with a review of tendencies in the design of broadcasting, television, and communication receivers, and descriptions of new kinds of receivers and circuits, including the intermediate frequencies. Design formulas for intermediate-frequency amplifiers are discussed in an appendix. The author was employed during the war in the Admiralty Signals Establishment.

Ocean Electronic Navigational Aids; Loran, Radiobeacon, and Radarbeacon Systems, and Loran, Radio-Direction-Finder, and Radar Ship Equipment. Revised Ed. (U.S., Coast Guard, CG 157.) Washington, U.S. Govt. Printing Office, 1949. 73 pp., illus., diagrs. $0.50.

This revised edition of a pamphlet first issued in 1945 is larger by 25 pages and includes advisory minimum specifications for marine radar, Loran receiving equipment, and direction-finder equipment. The pamphlet is intended for the maritime industry, commercial air lines, and others interested in the application of electronic navigation aids. Descriptions of each type of equipment are detailed, and the operating characteristics are thoroughly explained.

A COMPLETE MEDIA PACKAGE
FOR YOUR
Aviation Marketing Program

AERONAUTICAL ENGINEERING REVIEW

For your monthly advertising messages to the aircraft industry's engineering and design personnel—the men who influence buying.

AVIATION
MARKET
BOOK
Now Available!

16 pages of FACTS on your market and the REVIEW.

Write for your free copy TODAY!

AERONAUTICAL ENGINEERING CATALOG

Prefiles and distributes your aircraft products catalog to aviation's buyers and specifiers.

6,000 copies are distributed annually to aircraft engineers, designers, technicians and purchasing agents in all leading aircraft, engine and parts companies, Government aviation departments and leading air lines.

Write for your free copy of 12-page MARKET BOOK giving full details.

OFFICIAL PUBLICATIONS:
INSTITUTE OF THE AERONAUTICAL SCIENCES
2 East 64th Street New York 21, N. Y.

ENGINEERING PRACTICES

Engineering Workshop Drawing. H. Binns. London, English Universities Press, Ltd., 1949. 2 Vols., 96, 129 pp., diagrs. Vol. 1, 7*s.* 6*d.*, Vol. 2, 9*s.* 6*d.*

These volumes are designed for the apprentice working in engineering shops, who is required to read drawings and make simple detailed drawings or sketches in orthographic, isometric, oblique, or pictorial projection from drawings received from the drafting room. The first volume takes up fundamentals, including some geometry, and proceeds into simple machine parts and welding. The second volume takes up more complicated elements, including involute and cycloidal curves, bearings, couplings, hydraulic joints, and jigs, tools, and fixtures. A large number of illustrative examples and exercises is included.

FUELS & LUBRICANTS

A.S.T.M. Standards on Gaseous Fuels. Philadelphia, American Society for Testing Materials, 1949. 98 pp., diagrs. $1.15.

The following standards are reprinted from *A.S.T.M. Standards* and *Tentative Standards*—D 900–48: Test for Calorific Value of Gaseous Fuels by the Water-Flow Calorimeter—D 1070-49T. Tests for Specific Gravity of Gaseous Fuels (Tentative)—D 1071-49T. Methods for Measurement of Gaseous Fuel Samples (Tentative).

GENERAL WORKS

The Human Use of Human Beings; Cybernetics and Society. Norbert Wiener. Boston, Houghton Mifflin Company, 1950. 241 pp. $3.00.

This book is closely related to the author's *Cybernetics, or Control and Communication in the Animal and the Machine*, published in 1948. Mathematical symbolism and ideas are largely omitted because the layman is particularly addressed, and emphasis is placed on the social consequences of Dr. Wiener's extensions of communication theory into the human nervous system, industrial production, and the complete realization of his powers by man. Dr. Wiener uses the widest possible range of reference points in mathematics, science, history, etc.

The Professional Engineer of the Future. William Edward Bullock. New York 3, N.Y., 65 University Place, The Author, 1950. 82 pp. Mimeographed. $3.00.

The objective of this study is stated to be the discovery, from the record and trend, of the social invention or inventions that must be made by the engineering profession through its organized groups and agencies. This is envisioned as the next great invention after scientific management. The more rapid advancement of unity in the engineering profession depends upon the development of a homogeneous political advisory body, aiming for an adequately and intelligently advised engineering practice.

INSTRUMENTS

Symposium on Dynamic Stress Determinations. (Special Technical Publication No. 104.) Philadelphia, American Society for Testing Materials, 1950. 61 pp., diagrs. $1.50.

The purpose of this symposium, held at San Francisco in October, 1949, is to present in a single source pertinent information on the scope, applicability, possibilities, and limitations of electronic measuring and recording devices. Contents: Analysis and Interpretation of Dynamic Records, H. C. Roberts. Survey of Pick-ups for Dynamic Physical Measurements, G. E. White. Selection of Recording Equipment for Dynamic Testing, K. D. Schwartzel. Some Examples of Dynamic Testing in the Field of Materials and Structures, Douglas McHenry and H. E. Hosticka. 29 references.

LAWS & REGULATIONS

Civil Air Regulations and Reference Guide for A & E Mechanics. Los Angeles, Aero Publishers, Inc., 1950. 120 pp. $1.75.

This compilation includes the texts of Civil Air Regulations on airworthiness certificates; airplane, engine, propeller, and equipment airworthiness; maintenance, repair, and alteration of certificated aircraft, engines, propellers, and instruments; mechanic certificates; repair-station rating; and air-traffic rules. Some 265 questions, with answer keys, are included in the reference guide section, and a periodic aircraft inspection report form and an application form for airworthiness certificate or annual inspection of an aircraft are also included.

Civil Air Regulations and Reference Guide for Pilots. Los Angeles, Aero Publishers, Inc., 1949. 134 pp. $1.50.

This compilation includes the text of Civil Air Regulations on airworthiness certificates, pilot certificates, air-line pilot rating, lighter-than-air pilot certificates, physical standards for airmen, general operation rules, transportation of explosives and other dangerous articles, air-traffic rules, and notices and reports of aircraft accidents and missing aircraft. The reference guide includes information on the pilot written examination, 212 typical questions with answer key, and the text of Civil Aeronautics Bulletin No. 32, Fundamentals of Elementary Flight Maneuvers.

Pilots' Handbook of Civil Air Regulations. Arlington 4, Va., P.O. Box 2092, Ross Publications, 1950. 80 pp. $0.35.

This pocket sized book contains the *U.S. Civil Air Regulations* as follows, with a convenient alphabetical index of four pages to all parts: Part 20, Pilot Certificates; Part 29, Physical Standards for Airmen; Part 43, General Operation Rules; Part 60, Air Traffic Rules; and Part 62, Notice and Reports of Aircraft Accidents and Missing Aircraft.

MANAGEMENT & FINANCE

Industrial Organization and Management. Lawrence L. Bethel, Franklin S. Atwater, George H. E. Smith, and Harvey A. Stackman, Jr. 2nd Ed. New York, McGraw-Hill Book Company, Inc., 1950. 851 pp., illus., diagrs. $5.50.

This new edition of a textbook first published in 1945 is larger by 150 pages and contains new sections on production processes, waste control, maintenance of plant and equipment, replacement of equipment, and cost reduction. A new chapter is included in the first part on American industry, covering the relations of free enterprise, government, and labor in the control of industry. Material on sales, quality control, and physical facilities has been reworked, and the seven chapters on the administration of industrial relations has been completely revised. Bibliographies have been brought up to date and include about 325 references to books and articles.

MATERIALS

American Society for Testing Materials, Proceedings, Vol. 49, 1949. Philadelphia, The Society, 1950. 1,239 pp., diagrs. $12.

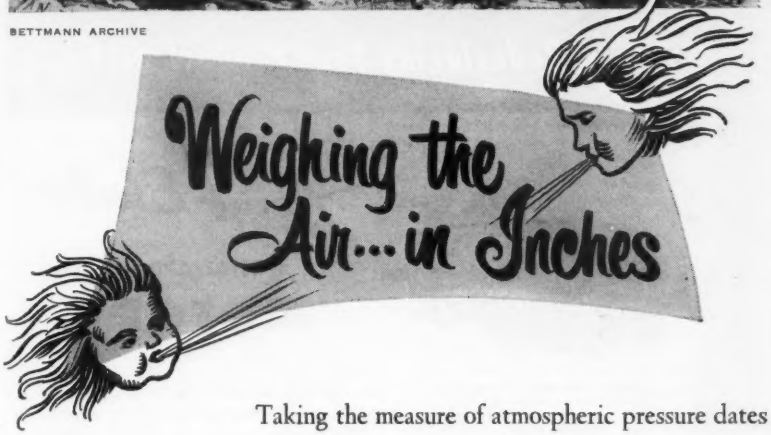
Partial Contents: Residual Stresses in Metals, William Marsh Baldwin, Jr. Effect of Manufacturing Practice on Creep and Creep-Rupture Strength of Low-Carbon Steel, G. V. Smith and E. J. Dulis. The Effects of Temperature and Material Structure on the Fracture Properties of Medium-Carbon Steel, Julius Miklowitz. The Influence of Conditions of Heat Treatment and Hot-Cold Work on the Properties of Low-Carbon N 155 Alloy at Room Temperature and 1200°F., J. W. Freeman, E. E. Reynolds, D. N. Frey, and A. E. White. The Influence of Fluctuations in Stress Amplitude on the Fatigue of Metals, T. J. Dolan, F. E. Richart, Jr., and C. E. Work. The Effects of Metallizing Procedures on the Fatigue Properties of Steel, W. Lee Williams. A New High-Speed Metal Fatigue Testing Machine for Unsymmetrical Bending Studies, G. R. Gohn and E. R. Morton. The Time Delay for the Initiation of Plastic Deformation at Rapidly Applied Constant Stress, D. S. Clark and D. S. Wood. Elastic Fracture Toughness Studies of Stainless Steel, Carl W. Muhlenbruch. Dynamic Creep and Creep Rupture Properties of Temperature-Resistance Materials Under Tensile Fatigue Stress, B. J. Lazan. Effect of Pulsating Loads on the Creep Characteristics of Aluminum Alloy 14 S-T, M. J. Manjoine. Fatigue Characteristics of Aluminum Alloy 75S-T6 Plate in Reversed Bending As Affected by Type of Machine and Specimen, T. T. Oberg and R. J. Rooney. Creep and Stress-Rupture Investigations on Some Aluminum Alloy Sheet Metals, J. E. Dorn and T. E. Tietz. The Influence of Vibration on the Creep of Lead, J. Neill Greenwood. A Method for Evaluating the Surface and Volume Resistance Characteristics of Solid Dielectric Materials, William G. Amey and Ferdinand Hamburger, Jr. Flexure Testing of Plastic Materials, J. W. Westwater. Damping and Resonant Load-Carrying Capacities of Polystyrene and Other High Polymers, J. A. Sauer and W. J. Oliphant. The Creep Characteristics of Compression Molded Polyethylene, G. R. Gohn, J. D. Cummings, and W. C. Ellis. Creep-Time Relations for Polystrene Under Tension, Bending, and Torsion, Joseph Marin and G. E. Cuff. Some Problems in the Sampling of Bulk Materials, Louis Tanner and W. Edwards Deming.

METALS & ALLOYS

The Properties of Aluminium and Its Alloys. 3rd Ed. (Information Bulletin No. 2.) London, The Aluminium Development Association, 1949. 55 pp. 1s.

This bulletin was last revised in 1944. The physical and mechanical properties of aluminum casting and wrought alloys, durability, and methods of working alloys in relation to properties are presented, with 15 extensive tables of data. Average weights of aluminum alloys in standard forms and correlations of British aircraft and other standards are presented in appendixes.

BETTMANN ARCHIVE



Taking the measure of atmospheric pressure dates back to Torricelli's mercury column in 1643.

Subsequently, the aneroid—or fluidless—barometer was developed. But while it offered a much higher degree of portability, there was also a corresponding sacrifice of accuracy.

In fact, not until the advent of the first sensitive altimeter—engineered by Kollsman—was the aneroid diaphragm recognized to be an extremely reliable gauge of pressure differential.

The pointer of the Kollsman 80,000-foot Sensitive Altimeter accurately indicates a change of fifty feet while the positive diaphragm movement is only one ten-thousandth of an inch.

This outstanding example of precision engineering and careful manufacturing technique typifies Kollsman leadership in the fields of aircraft instrumentation, optics and electro-mechanical controls.

KOLLSMAN AIRCRAFT INSTRUMENTS

PRODUCT OF

SQUARE D COMPANY

ELMHURST, NEW YORK GLENDALE, CALIFORNIA

A bibliography of 15 articles on fatigue and high-temperature properties is included.

METEOROLOGY

Methods in Climatology. V. Conrad and L. W. Pollak. 2nd Ed. Cambridge, Harvard University Press, 1950. 459 pp., illus., diagrs. $7.50.

In this new edition of a book first published in 1944, the text has been fully revised, and numerous additions have been made, including a new chapter on Aids to Computation and an entirely new part of 103 pages on Computing Devices and Periodography. The use of slide rules, accounting machines, calculating machines, and, particularly, punched-card machines and methods is reviewed in one of these new chapters. There are three extensive chapters dealing with hidden periodicities, test of significance, mutually dependent variables, secondary analysis, and determination of periods with the aid of autocorrelation. Other new material includes discussions of the Gaussian curve, arithmetic probability paper, cumulative summation, hythergraphs, and the hyetographic curve. The original aim—to furnish a guide for dealing with the original data of observation—has been retained. Dr. Conrad is with Harvard University, and Dr. Pollak is with the Dublin Institute for Advanced Studies.

Atmospheric Turbulence. O. G. Sutton. London, Methuen & Company, Ltd.; New York, John Wiley & Sons, Inc., 1949. 107 pp. $1.50.

Turbulence of the lower atmosphere is discussed as a branch of mathematical physics, with particular reference to aspects of the subject which are significant for future development. Introductory chapters deal with turbulence in general, the meteorology of the lower atmosphere, and early theories and their application to large-scale phenomena. Mixing length and statistical theories of turbulence, diffusion in the atmosphere near the ground, and turbulence in a variable-density gradient are discussed in the later chapters. Numerical data for flow near the surface of the earth are presented in an appendix. The author is Bashford Professor of Mathematical Physics at the Military College of Science in Shrivenham.

POWER PLANTS

RECIPROCATING

Aircraft Engine Maintenance and Service. Rollen H. Drake. New York, The Macmillan Company, 1950. 237 pp., illus. $5.00.

This book covers the various branches of aircraft reciprocating engine maintenance and service, including top overhaul, disassembly, overhaul inspection, repair and replacement of parts, assembly, and engine run-in after overhaul. Coverage of the various types of inspections required is complete. Fundamentals of the theory and operation of engines are included where required for clarification. The book is written in nontechnical language, and 219 clear illustrations are included.

PRODUCTION

Resistance Welding; Designing, Tooling and Applications. Wallace A. Stanley. New York, McGraw-Hill Book Company, Inc., 1950. 329 pp., diagrs. $7.50.

Designed to assist designing, manufacturing, tooling, and welding engineers in the economic and efficient production of metal products, this book is intended to acquaint engineers with each others' problems. Equipment and materials and the basic concepts behind resistance welding are first explored, followed by six chapters on design considerations. The application of basic information and design principles to tooling and production are taken up in the final chapters. The book contains 792 photographs and line drawings of tools, methods, and procedures, reflecting the best standard practices. The author is consultant on product design, tooling, and manufacturing operations to the Progressive Welder Company.

Gear Cutting Practice. Fred H. Colvin and Frank A. Stanley. 3rd Ed. New York, McGraw-Hill Book Company, Inc., 1950. 532 pp., illus., diagrs. $4.75.

In this new edition of a book last revised in 1943, additional material has been included on carbide-tipped hobs, hobbing speeds and feeds, new bevel-gear standards, new methods of cutting bevel gears, new data on involute splines, and new shaving and lapping methods of finishing gear teeth. Newly designed gear-cutting and finishing machines and improved methods of checking the accuracy of gears are described. The material has been largely rearranged.

The Principles of Stretch-Wrap Forming. Redondo Beach, Calif., Hufford Machine Works, Inc., 1950. 87 pp., illus., diagrs. $5.00.

Specifications, selection, tooling, and operation of Hufford stretch-wrap forming machines are presented, with typical applications. Typical applications with 24 S-Q, stainless steel, 61 S-T, and 75 S-T sheet include interduct, cowling, wingtip, inter-scoop-duct, and droppable fuel-tank skins; stabilizer, fuselage-to-wing, and pilot's canopy fillets; tailpipe fairings; fuselage angle attachments; and fuselage sheet webs.

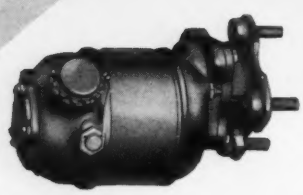
REFERENCE LITERATURE

DICTIONARIES

A German-English Dictionary for Chemists. Austin M. Patterson. 3rd Ed. New York, John Wiley & Sons, Inc., 1950. 541 pp. $5.00.

This new edition of an excellent dictionary last revised in 1935 is larger by 130 pages and contains some 17,000 new terms, bringing the total covered to about 59,000. Though designed primarily for chemists and chemical engineers, it contains considerable material from related fields. Additions have been made extensively in chemical technology, electronics, and warfare, but numerous terms are included in such fields as aeronau-

Check These 6 Advantages of Redesigning Your Product with a...



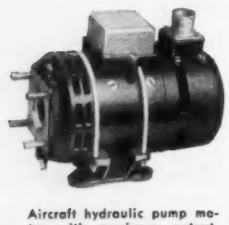
Lamb Electric
SPECIAL APPLICATION
MOTOR

Sturdy and reliable, explosion proof construction, helical geared fuel transfer pump motor.

By using Lamb Electric *motor parts* or a complete *frame motor* —engineered for the *exact* requirements of your application—you may gain these advantages:

IN THE MOTOR—
1. Reduced cost, weight, space.
2. Exact mechanical and electrical characteristics.
3. Thorough dependability.

IN THE PRODUCT—
4. Better performance.
5. Improved eye-appeal.
6. Compactness, less weight.



Aircraft hydraulic pump motor with maximum output, minimum weight. Adaptable to many heavy-duty industrial applications.

Our engineering department will be glad to team up with yours to help achieve these results. *The Lamb Electric Company, Kent, Ohio.*

They're Going Into America's *Finest* Products

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

tics, astronomy, ceramics, explosives, manufacturing, mechanics, mathematics, metallurgy, photography, and biological sciences. The policy of including useful general words, such as prepositions, three tenses of simple irregular verbs, abbreviations, and prefixes and suffixes has been continued. The list of German vocabularies consulted is comprehensive and includes such recent ones as De Vries, Leidecker, Regen, and Singer.

DIRECTORIES

Pacific Coast and Inland Aviation Directory, 1950. Temple City, Calif., 3303 Tyler Avenue, Pacific Coast Aviation Publishing Company, 1950. 168 pp. $2.00.

About 100 pages of this useful official directory of the California Aviation Trades Association are devoted to a complete listing of airports in Arizona, California, Oregon, and Washington. Flying data, names of personnel, and names of operators, dealers, and services available at each airport are included. Alphabetical indexes of airports in each state are provided. Alphabetical and classified lists are included of manufacturers of aircraft, parts, components, and supplies, distributors, air lines, insurance companies and agents, Federal and State Government agencies, and state associations.

The Engineer Directory and Buyers Guide, 1950. London, The Engineer, 1950. 320 pp. 2*s*. 6*d*. (Free to subscribers.)

This is a general directory of firms and their products who advertise in *The Engineer*. About 1,000 firms are represented, including suppliers of raw materials, machine tools, and electronic and other equipment. A list of about 350 associations connected with the engineering industry and a list of trade names and marks are included.

HISTORY

The Army Air Forces in World War II. Volume 4, The Pacific: Guadalcanal to Saipan, August 1942 to July 1944. Chicago, University of Chicago Press, 1950. 825 pp., illus. $6.00.

This is the third of seven planned volumes to be published and the first dealing exclusively with the Pacific theater. The first volume, *Plans and Early Operations*, includes the early phases of the Pacific war. This volume takes up the history as the Japanese attack was reaching into the lower Solomons and southeastern New Guinea and closes as MacArthur's forces were preparing to return to the Philippines and B-29 bases were in preparation in the Marianas. In all, six air forces were involved: the Eleventh in the move along the Aleutians to Kiska; the Fifth with MacArthur's Southwest Pacific forces; the Seventh and Thirteenth in the Central and South Pacific; the Tenth in India and Burma; and the Fourteenth in China. The book was prepared by the Air Force Historical Division under the editorship of Wesley Frank Craven of New York University and James Lea Cate of the University of Chicago.

The Pratt & Whitney Aircraft Story. East Hartford, Conn., Pratt & Whitney Aircraft Division, United Aircraft Corporation, 1950. 173 pp., illus.

In this history, compiled on the twenty-fifth anniversary of the company, is recorded a good deal of previously scattered and unpublished information on the development of the aircraft industry, and particularly the aircraft-engine industry. The design achievements of George J. Mead and Andrew V. D. Wilgoos and their principal assistants are given in detail. The story of the growth of the company under the leadership of its founder, Frederick B. Rentschler, and of its relationship with transport, racing, and Air Force and Navy airplane development, furnishes a useful addition to the historical record of American aviation. The photographic illustrations are excellent.

RESEARCH

The Principles of Scientific Research. Paul Freedman. Washington, Public Affairs Press, 1950. 222 pp. $3.25.

This book is designed for scientists just entering the field of research. Introductory chapters deal with the nature of research and its history, research and society, research and philosophy, and the mental approach. Two chapters are devoted to the planning of research, followed by discussions on organization, general conditions of experimentation, accuracy and economy of effort, and the minimum number of essential observations. The final chapter, Patrons, deals with the financial support of research. This is a thoughtful work, written out of thirty years of experience in industrial research. It was first published in London in 1949.

Management of Industrial Research; A Selected and Annotated Bibliography. Cambridge 42, Mass., Arthur D. Little, Inc., 1950. 14 pp.

Prepared principally for the research director and those in charge of research policy, this bibliography includes 96 items, each briefly described. The organization and control of research, the research program, the research laboratory, and research economics are among the topics covered.

Proceedings of the Symposium on Engineering Research, March 14-15-16, 1949. (Minnesota, University, Institute of Technology, Engineering Experiment Station, Bulletin No. 29.) Minneapolis, 1949. 114 pp.

Contents: The University, Industry, and Government as a Research Team, A. F. Spilhaus. Industry's Concept of Cooperative Research, H. N. Stephens. Phases of Cooperative Research Pertaining to Universities, J. E. Hobson. Phases of Cooperative Research Pertaining to Industries, E. C. Bain. Phases of Cooperative Research and Governmental Agencies, A. T. Waterman. Fundamental and Applied Research, C. C. Furnas. Industrial Projects Applicable to Cooperative Research, V. H. Schnee. Governmental Projects Applicable to Cooperative Research, O. C. Maier. Organization and Facilities for Engineering Research at the University of Minnesota, F. B. Rowley. The Function of University Personnel in Cooperative Research, C. E. MacQuigg and J. S. Owens. University Policies on Contracts, Patents, and Publications, W. T. Middlebrook. The Effect of University Policies on Industry, A. L. Elder. The Qualifications for Industrial Research Personnel, M. T. Carpenter. Training of Research Personnel in the Universities, H. F. Lewis.

SCIENCES, GENERAL

Workshop Engineering Calculations and Technical Science. Vol. 2. J. Stoney. London, English Universities Press, Ltd., 1950. 212 pp., illus., diagrs. 12*s*. 6*d*.

This volume covers a second and third year course in workshop engineering, covering strength of materials, power and motion transmission, machine efficiency, forces and velocities, friction and lubrication, energy, velocity and acceleration, and heat treatment of metals in the first half. The later chapters deal with logarithms, geometry of the circle, trigonometry, angles between 90° and 180°, the cone and pyramid, equations, quadratic equations, and graphic solutions of equations. The author is a lecturer in engineering and mathematics at the Wolverhampton and Staffordshire Technical College.

The Evolution of Scientific Thought, from Newton to Einstein. A. D'Abro. 2nd Ed. New York, Dover Publications, Inc., 1950. 481 pp., illus., diagrs. $3.95.

In this edition of a standard work first published in 1927, the chapter on the finiteness of the universe, in the part on the general theory of relativity, has been entirely rewritten and has been supplemented by a discussion of the expanding universe of the Abbé Lemaitre. Some unnecessary repetitions have been eliminated from the text, and errors have been corrected. The book is divided into four parts, dealing with Pre-Relativity Physics, The Special Theory of Relativity, The General Theory of Relativity, and The Methodology of Science.

MATHEMATICS

Analytic Geometry. Raymond D. Douglass and Samuel D. Zeldin. New York, McGraw-Hill Book Company, Inc., 1950. 216 pp., diagrs. $2.75.

This textbook presents the essentials of plane and solid analytic geometry simply and concisely, to impart the necessary background for a course in the differential and integral calculus. Numerous examples and exercises are provided, and various short tables are included in appendixes. The authors are, respectively, a Professor and Associate Professor of Mathematics at the Massachusetts Institute of Technology.

Progressive Mathematics. P. Clyne. London, Chapman & Hall, Ltd., 1950. 270 pp. 15*s*.

Following introductory chapters on Interdeterminate Quantities, Some Important Definitions, and General Laws of Differentiation, the author proceeds into the Differential Coefficient of x^n and two chapters on trigonometry. The Exponential; Maximum and Minimum Values, and Curvature; Infinite Series; Integration; First Applications of Integration; Conic Sections; Vectors—Notation—Hyperbolic Functions; Tricks of Integration, with an Algebraic Interlude for Partial Fractions; and Further Applications of Integration are the next chapters. The book ends with discussions of Fouriers Series, Harmonic Analysis, Partial Differentiation, and More Differential Equations. Appendix material includes equations and identities, relation between two variables, mensuration of the triangle, permutations and combinations, curves, polar coordinates, and determinates. Exercises are provided throughout, with answers, and dialogues are inserted to clarify certain parts of the text. The author is a lecturer in mathematics in the Engineering Department of Mid-Essex Technical College at Chelmsford.

Riemannian Geometry. Luther Pfahler Eisenhart. Princeton, N.J., Princeton University Press, 1949. 306 pp. $3.50.

In this reprint of a book originally published in 1926, errata have been corrected in the text and new material is presented in 29 appendixes covering 36 pages. The bibliography has been extended to include the period 1854 through 1949 and now contains about 250 references.

An Introduction to Probability Theory and Its Applications. Vol. 1. William Feller. New York, John Wiley & Sons, Inc., 1950. 419 pp. $6.00.

This first volume is restricted to the treatment of discrete sample spaces and discrete random variables, allowing presentation of the intuitive background and basic concepts without the concern of analytical difficulties, such as questions of measurability. About half of the book is devoted to an introduction, then the discussion proceeds into advanced topics, including recurrent events, random walk and ruin problems, infinite Markov chains, and the simplest time-dependent stochastic processes. A wealth of illustrative material is provided, including 340 problems, mostly with complete solutions. Dr. Feller is a professor of mathematics at Cornell University. The book grew partly out of research in probability theory sponsored by the Office of Naval Research.

Theory of Sets. E. Kamke. Translated by Frederick Bagemihl. New York, Dover Publications, Inc., 1950. 152 pp. $2.45.

This is a translation from the second German edition of Dr. Kamke's standard introduction, in which emphasis is placed on the concepts and principles of the general theory of sets. Classification of sets, equivalence of sets, relations among cardinal numbers, ordered sets, and their order types, and well-ordered sets and their ordinal numbers are among the topics discussed.

An Introduction to the Laplace Transformation; with Engineering Applications. J. C. Jaeger. London, Methuen & Company, Ltd.; New York, John Wiley & Sons, Inc., 1949. 132 pp., diagrs. $1.50.

This book is based on a course of lectures presented to engineers and physicists at the Na-

(*Continued on page 89*)

Corporate Member News

(*Continued from page 14*)

on the construction of the new Isla Verde Airport.

• Revamps Sales Area . . . **Scintilla-Magneto Division, Bendix Aviation Corporation,** has realigned its Mid-West territory. The 16 states concerned are now divided into two territories—the North Mid-West and the South Mid-West. Headquarters are located in Milwaukee.

• New Constellations . . . **Trans World Airlines, Inc.,** has purchased six additional Constellations from Lockheed Aircraft Corporation for delivery in 1951. Total cost will be approximately $6,000,000 . . . T.W.A. is scheduled to open a new sales territory in Australia and New Zealand with a sales office in Sydney.

• New Office . . . **United Air Lines, Inc.,** has opened a new ticket and reservations office at 7 W. 49th St., New York, N.Y.

• Temperature Control . . . An electronic temperature-control panel for aircraft, type AVE-105, is available from **Westinghouse Electric Corporation.** It is designed to control temperature within ±5°F. of the nominal setting, which is adjustable between 90° and 130°F. It is intended primarily for controlling window temperature in deicing and defogging installations. It weighs 2.75 lbs.

I.A.S. Sections

Cleveland-Akron Section

William A. Fleming, *Secretary*

The results of the election of officers of the Cleveland-Akron Section for the 1950–1951 year is as follows: Chairman, John H. Collins; Vice-Chairman (Akron), Robert S. Ross; Vice-Chairman (Cleveland), William A. Fleming; Secretary-Treasurer, Morris A. Zipkin; and Advisory Board, Willson H. Hunter and Abe Silverstein.

San Diego Section

Leon Wosika, *Secretary*

Sixty persons attended the June 15 forum meeting at which the topic, "Aeronautical Applications of Electrical Computers," was discussed. The panel consisted of Lloyd Hubbard, Representative, International Business Machines Corporation; Gregory Toben, Northrop Aircraft, Inc.; Rex Rice, Northrop Aircraft, Inc.; and Ralph Peterson, Consolidated Vultee Aircraft Corporation. Ben Ferber, of Convair, was the moderator.

With the great variety of problems confronting the aeronautical engineer today, this was a timely and interesting forum. In the discussion it was brought out that a telecomputing reader for film tracing which can be used to record directly the data on IBM cards was in a high state of development and would soon be available. A plotter is also being developed which will take data from the IBM machine and plot it in graphical form for quick and easy application. Concrete examples were presented by members of the forum, one of the most interesting being that shown by the Northrop representatives on Tail-Load Calculations. Slides were screened of the various machines now in use by the industry.

▸ **Air-Sea Rescue**—The 1950 Octave Chanute Award Winner, Comdr. Donald B. MacDiarmid, U.S.N., was the speaker at the August 3 dinner meeting, attended by 116 persons. Commander MacDiarmid's talk on "Problems of Air-Sea Rescue" included: operations in a typical air-sea rescue; brief analysis of sea-wave and swell motion; research and testing of seaplanes in rough-water operations; and seaplane design problems and needs for future improvement. A short film, *Offshore Landing of Seaplanes*, was shown.

Washington Section

Bernard Maggin, *Secretary*

The annual election of the Washington Section of the I.A.S. has been held. The Election Committee consisted of T. L. K. Smull and G. G. Kayten. Elected were: Chairman, Dr. J. P. Van Zandt; Vice-Chairman, A. Hyatt; Secretary, Donald Auld; Treasurer, Donald R. Eastman, Jr.

Dr. Van Zandt is Special Consultant to the Assistant Secretary of the Air Force for Civilian Aviation. Mr. Hyatt is Chief, Aviation Design Research Branch, Bureau of Aeronautics, Department of the Navy. Mr. Auld is with the Aerodynamics Laboratory, David Taylor Model Basin, Department of the Navy, and held the position of Treasurer of the Washington Section for the year 1949–1950. Mr. Eastman is with the Research and Development Board, Committee on Aeronautics.

M. B. Ames, Jr., was elected Section Representative to the Nominating Committee for Area Councilors. Mr. Ames is Chief, Aerodynamic Research Division, Headquarters of the N.A.C.A.

A meeting of the new officers and the retiring officers is planned for the near future to discuss past activities of the section and programming for the coming year.

Student Branches

Cal-Aero Technical Institute

The June 6 meeting was opened by Chairman John Sweeney, who introduced the guest speaker, C. T. Reid, Assistant to the President, Grand Central Aircraft Company. Mr. Reid presented a talk on "Atomic Energy," in which he discussed the various highlights of atomic energy and its application to the aircraft industry. The discussion was supplemented by a film, *Atomic Energy*, which showed the various aspects of nuclear fission and the significance of a chain reaction. One hundred and sixty students attended.

At the August 15 meeting, David K. Wong, Development Engineer, Aerojet Engineering Corporation, spoke on "The Aero Bee" and showed a film, *The Flight Tests of the Aero Bee*. Mr. Wong discussed the free-flight missiles that his company is developing, including the Aero Bee Rocket. Chairman Sweeney presided; 75 persons attended.

Illinois Institute of Technology

The May 25 meeting was called to order by Chairman Paul Margolis. The following officers were elected: Chairman, Frank K. Halwax, and Secretary-Treasurer, Lawrence J. Rawlings.

Northrop Aeronautical Institute

The guest speaker on August 1 was L. A. Carter, Manager, Douglas Aircraft Company, Inc. In his talk on "The Need for Specialization in Aeronautical Engineering," Mr. Carter stated that, although the engineer has completed his formal schooling, there is the need for continued studying. Facilities, he stated, are available in most areas where he can continue learning new engineering developments.

Parks College of Aeronautical Technology

Robert A. Killoren, Secretary, Department of Aeronautical Engineering, Parks College of Aeronautical Technology, was the speaker at the August 10 meeting. In his lecture on "Mathematical Techniques Applied to Lofting," Mr. Killoren first outlined the graphical method of lofting as used in the past and in the present. He then discussed other methods, including the analytical method.

Riddle McKay College of Aeronautics

On August 1 and August 8, a new I.A.S. Student Branch was organized

BRANIFF International AIRWAYS
LOVE FIELD • DALLAS 9, TEXAS
November 11, 1949
Surface Combustion Corporation
2375 Dorr Street
Toledo 1, Ohio
Attention: Mr. James W. Ashby, Sales Manager
Gentlemen:
Braniff International Airways experience with "Janitrol" Surface Combustion heaters on DC-6 and DC-4 airliners, flying from Chicago to Rio de Janeiro, Brazil, under varying weather conditions, has been very good. Owing to this very satisfactory operation, we are now installing your heaters on all of our DC-3 planes.
During the first nine months of this year, in more than 15,000 hours of DC-4 flight service, we enjoyed a very satisfactory performance from "Janitrol" heaters. As we have three heaters per plane, this record covers 46,000 heater hours of operation that has been practically trouble-free.
"Janitrol" heaters on our DC-6 (El Conquistador) planes have also performed satisfactorily. Braniff has had no major troubles with DC-6 cabin heaters in some 8,500 hours this year. The wing and tail anti-icing heaters also showed the same fine record.
The record of "Janitrol" heating units on Braniff Airways planes is all the more remarkable when you consider the varied conditions under which our planes operate. From Chicago to the Houston, Texas Air Gateway between the Americas, we serve Tri-Cities, Burlington, Kansas City, Topeka, Wichita, Ponca City, Oklahoma City, Tulsa, Dallas and Fort Worth. From Denver to Memphis, we serve Colorado Springs, Pueblo, Amarillo, Lubbock, Muskogee, Fort Smith and Little Rock. These routes cover some 3,700 miles.
Braniff's El Conquistador (DC-6) and El Intercontinental (DC-4) planes serve six Latin American countries: Cuba, Panama, Ecuador, Peru, Bolivia and Brazil. "Janitrol" heaters must warm cabins at "the highest airport in the world" (13,398 feet) at La Paz, Bolivia, and on the mammoth 2,344-mile non-stop hop over the lofty Andes, between Lima, Peru and Rio.
There is nothing finer, nothing faster between the Americas than Braniff Airways' airliners. And we think there is nothing finer than "Janitrol" heaters that contribute so much to Braniff's operations.
Yours very truly,
BRANIFF AIRWAYS, INC.
Wm. Maxfield
Director of Maintenance & Engineering
Wm:rl
1928 – BRANIFF'S 21ST YEAR – 1949
BRANIFF International AIRWAYS
NC-88573

"nothing finer"

Take 28 seconds and read the above letter. It's worth it, for it forges another strong link in the long chain of "final evidence" that Janitrol aircraft heaters do the jobs they're built for—dependably, and more often than not, well beyond normal expectancy . . . Specific, practical help on your aircraft heating problems—military or commercial—from design through field service—is *yours to command* from your nearest Janitrol representative whose name appears below. Call him. He can help you most in the preliminary design stage of your aircraft.

Janitrol

AIRCRAFT AND AUTOMOTIVE HEATERS *with the whirling flame*

AIRCRAFT-AUTOMOTIVE DIVISION • SURFACE COMBUSTION CORP., TOLEDO 1, OHIO

F. H. Scott, New York, N. Y., 225 Broadway; C. B. Anderson, Kansas City, Mo., 1438 Dierks Building; I. A. Curtin, Hollywood, Calif., 7046 Hollywood Blvd.; Frank Deak, P. A. Miller, Central District Office, Engineering Development and Production, Columbus, Ohio; Headquarters, Toledo, Ohio.

with James C. Addison, Head, Physics Department, Riddle McKay, as Honorary Chairman.

The following members were elected to office: Chairman, Joseph William Justin; Vice-Chairman, John B. Wright; Secretary, Donald E. Morgan; and Treasurer, Sebastian LaBella.

The following committees were appointed: Meetings and Papers Committee, William Lewis Staples (Chairman), Donald L. Ellenberger, and Frank E. Haka; and Membership Committee, Joseph Rudolph Able (Chairman), Charles F. Erlandson, and Wallace E. Dyer.

Stewart Technical School

On August 9, the following officers were elected: Chairman, Stanley Okarma; Vice-Chairman, Karl H. Jurgenson; and Secretary-Treasurer, George J. Setescak.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Transferred to Associate Fellow Grade

Geyer, Leo A., M.S. in Ae.E., Asst. Chief of Aerodynamics, Grumman Aircraft Engineering Corp.

Hutton, Richard, Chief Development Engineer, Grumman Aircraft Engineering Corp.

Mead, Lawrence Myers, Jr., C.E., Project Engineer, Grumman Aircraft Engineering Corp.

Miles, Edward R. C., Ph.D., Research Contract Dir., Institute for Cooperative Research, The Johns Hopkins University.

Thompson, Edward S., M.S. in M.E., Mgr. of Sales, Aircraft Gas Turbine Div., General Electric Co.

Tifford, Arthur N., B.E.E., Associate Prof. of Aero. Engineering, The Ohio State University.

Elected to MEMBER Grade

Aldrich, Jerry F. L., M.S. in Aero., Research Engineer, Navy Research Project, University of Southern California.

Collinsworth, Edward R., B.S. in C.E., Engineering Designer, Consolidated Vultee Aircraft Corp. (Fort Worth).

Feldmann, Fritz K., Ph.D. in Ae.E., Group Leader of Experimental Aerodynamics, North American Aviation, Inc.

Freel, Charles L., Mgr.—Field Engineering, Lord Manufacturing Co.

Kearns, John P., B.S. in M.E., Power Plant Analytical Engineer, Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Kuhn, W. E., Ph.D. in Chem. Engineering, Mgr., Technical & Research Div., The Texas Co.

Link, Edwin A., President, Link Aviation, Inc.

Lurie, Harold, Ph.D., Asst. Engineer, The RAND Corp.

McMaster, Alexander, B.S., Engineering Designer, Consolidated Vultee Aircraft Corp.

Miele, Angelo, Dr. in Ae.E., Senior Project Engineer, Instituto Aerotecnico (Argentina).

Neudeck, Gene T., B.S.Ae.E., Sales Engineer, Aeroproducts Div., General Motors Corp.

Span, Robert E., B.S. in E.E., Development Engineer & Group Leader, Westinghouse Electric Corp.

Transferred to MEMBER Grade

Lentini, John, Grumman Aircraft Engineering Corp.

Lew, Henry G., Ph.D., Asst. Prof. of Aero. Engineering, The Pennsylvania State College.

Lucas, Thomas E., Aero. Field Engineer, Sperry Gyroscope Co. Div., The Sperry Corp.

Micks, William R., M.S.Ae.E., Asst. Engineer, The RAND Corp.

Snyder, Melvin H., Jr., M.S. in Ae.E., Acting Head, Department of Aero. Engineering, University of Wichita.

Tyler, Clarence M., Jr., Ph.D. (Math. & Engrg.), Asst. Prof. of Mechanical Engineering, Carnegie Institute of Technology.

Elected to Associate Member Grade

Stainton, John R., Mgr., North America, British Overseas Airways Corp.

Transferred to Technical Member Grade

Abel, Calvin J., B. of Ae.E., Electrical Installer, Consolidated Vultee Aircraft Corp.

Allen, Richard L., B.S.Ae.E., Aero. Engineer GS-5, Technical Service Department, Naval Air Missile Test Center (Pt. Mugu).

Anderson, Raymond, B.S., Jr. Engineer, Boeing Airplane Co. (Seattle).

Ballinger, J. R., S.B.

Bauer, Robert L., A.E., Senior Detailer, McDonnell Aircraft Corp.

Benenson, David M., S.B. (Aero.), Project Engineer, Southern California Cooperative Wind Tunnel, California Institute of Technology.

Bennett, Willard B., B.S., Engineering Draftsman "A," Consolidated Vultee Aircraft Corp. (Fort Worth).

Bills, Richard L., Jr.

Bishop, Harold E., B.A.E., Vibrations Engineer, Piasecki Helicopter Corp.

Boegel, Leonard E., B.A.E., Service Liaison Man "A," Consolidated Vultee Aircraft Corp. (Fort Worth).

Bonk, Casimir J., B. of Ae.E., Engineer, Boeing Airplane Co. (Seattle).

Brown, Robert E., B.S. in Ae.E., Technical Writer "A," Consolidated Vultee Aircraft Corp. (Fort Worth).

Bryan, W. C., Lt. Comdr. & Naval Aviator, U.S.N.; Administration Officer, Fleet All-Weather Training Unit (Pacific).

Bue, Edward A., Jr., B.A.E.

Bulmer, Harry R., Capt., Aircraft Maintenance Officer & Pilot, U.S.A.F.

Callahan, J. Fred, Jr., B.A.E.

Campbell, A. J., B.A.Sc. (Aero. Eng.), Flying Officer, R.C.A.F.

Charette, Franklin M., B.S. in Ae.E., Aviation Cadet, U.S.A.F.

Chikar, James E., B.S.M.E., Engineering Trainee, Allegheny Ludlum Steel Corp.

Cicero, Edward L., B. of Ae.E.

Clanton, Neil A., B. of A.E., Mathematician, Consolidated Vultee Aircraft Corp. (Fort Worth).

Cooper, Wilson D., B.S.

De Luca, Neil J., B.Ae.E.

Demayo, Miguel J., S.B.Ae.E.

Dougall, W. S., Ae.E., Jr. Engineer, Boeing Airplane Co. (Seattle).

Durran, Donald A., B.S., Design Engineer, Aerojet Engineering Corp.

Dwyer, Howard I., Jr., B.S.

Flickinger, Samuel J., Jr., B. of Ae.E.

Fong, James, B.S.

Foss, Robert N., 1st Lt. & Aircraft Maintenance Officer, U.S.A.F.

Gabel, James P., B.S., Jr. Engineer, Boeing Airplane Co. (Seattle).

Gale, Lauriston H., Draftsman, Lyon-Raymond Corp.

Galli, Charles V., B. of A.E., Jr. Engineer, Piasecki Helicopter Corp.

Gayes, George P., B.Ae.E.

Glasson, Clyde L., B.S. in M.E., Engineering Draftsman, Ryan Aeronautical Co.

Goodale, Bruce A., B. of Ae.E., Engineer, Design Department, Doman Helicopters, Inc.

Hale, Roy E., Jr., B.S. in Ae.E., 2nd Lt., U.S.A.F.

Hamilton, Laurence E., B.S., Mathematician, Northrop Aircraft, Inc.

Harasyko, John, B.A.E., Aerodynamicist, The Kaman Aircraft Corp.

Harvey, Erskine A., B.S.M.E. (Aero.), Jr. Engineer, Wright Aeronautical Corp. Div., Curtiss-Wright Corp.

Hayes, Robert B., B. of Ae.E., Aircraft Assembler, Consolidated Vultee Aircraft Corp.

Hirtzer, Hank, M.S., Stress Analyst, North American Aviation, Inc.

Hogshead, Fred G., B.S.Ae.E., Engineering Technician, Lockheed Aircraft Corp.

Hollinger, James A., B.M.E.

Horsch, Frank J., Jr., Stress Engineer, Sikorsky Aircraft Div., United Aircraft Corp.

Hveding, Dick, M.S.Ae.E.

Jacobs, George, Draftsman, Norden Laboratories (White Plains).

Kafoury, Sam P., Jr., B.S.

Kelleher, James F., B.S., Jr. Aero. Engineer, Personal Aircraft Research Center, A. & M. College of Texas.

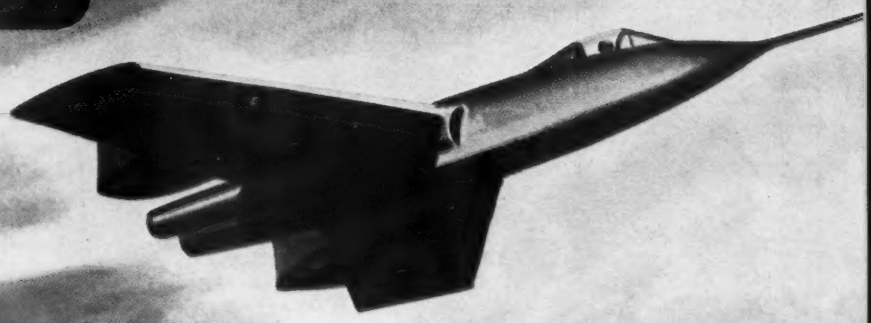
Keppel, Robert E., B. of Ae.E., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

King, James J., B.S., 2nd Lt. & Pilot Trainee, U.S.A.F. (Connally Air Force Base).

Kirkpatrick, James E., A.A. in Ae.E.

Bendix Products Division

FIRST IN FUEL METERING



LEADER IN LANDING GEAR

Stromberg* Injection Carburetors
Speed-Density Fuel Metering Unit
Fuel Metering Unit for jet engines
Segmented Rotor Brakes
Pneudraulic* Shock Absorbing Struts
Landing Gear Wheels for all types of airplanes
*REG. U. S. PAT. OFF.

Setting the Pace in America's Most Progressive Industry!

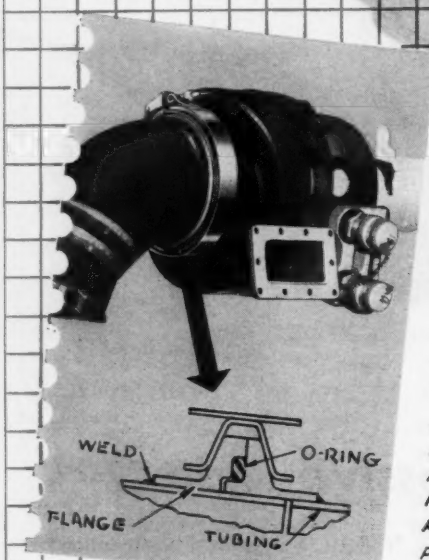
Tomorrow's aircraft—jets of unbelievable speeds, transports of gigantic size—are now on the drawing boards. And the task of creating new fuel metering systems and landing gear for many of these planes-in-the-making has been entrusted to the Bendix Products Division of Bendix Aviation Corporation.

Here, at Bendix Products, is a proved combination of creative engineering and quality production in these highly specialized fields. Let this Bendix skill and experience in the development of carburetion, fuel metering, shock-absorbing struts, wheels and brakes help you keep America's aviation the leader of the world.

BENDIX · PRODUCTS DIVISION · SOUTH BEND
AVIATION CORPORATION

Export Sales: Bendix International Division, 72 Fifth Ave., New York 11, N. Y.

ENGINEERS NOTEBOOK



QUICK COUPLING FOR TURBINE DUCT

MARMAN V-BAND COUPLING WITH QUICK COUPLER LATCH PROVIDES LIGHT-WEIGHT POSITIVE SEAL WITH FAST ASSEMBLY AND DISASSEMBLY.

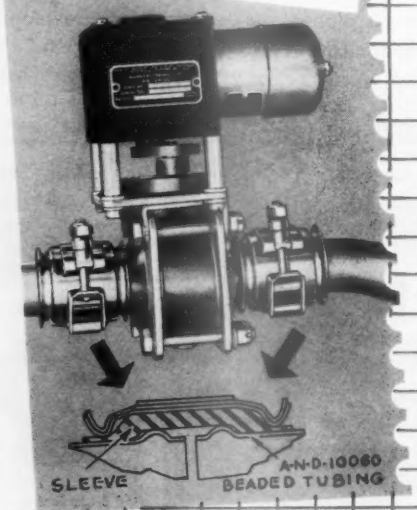
DESIGNED FOR USE ON ROLLED OR MACHINED FLANGES.

SPECIAL GASKETS AVAILABLE TO ACCOMMODATE VARIOUS HIGH P.S.I. AND TEMPERATURE REQUIREMENTS.

Photo courtesy Airesearch.

POSITIVE SEAL FOR AIR VALVE DUCT

MARMAN CHANNEL BAND COUPLINGS IDEAL FOR JOINING AND 10060 BEADED TUBES AND DUCTS. COUPLING ALLOWS A SMALL AMOUNT OF MISALIGNMENT AND MANUFACTURING TOLERANCE. DIFFERENT SLEEVES AVAILABLE FOR VARYING REQUIREMENTS... TO ACCOMMODATE TEMPERATURES FROM -100°F TO 500°F. PRESSURES TO 400 P.S.I. OR PROVIDE OIL AND FUEL RESISTANCE.



Save cost and design time with Marman

FOR INFORMATION WRITE DEPT. R-11.

THE BEST CLAMPS, STRAPS AND COUPLINGS

MARMAN PRODUCTS CO. INC.

940 W. FLORENCE AVENUE
INGLEWOOD, CALIFORNIA

5

Kuhta, Steven R., B. of Ae.E., Stress Analyst, Chase Aircraft Co., Inc.

Landphair, Lee C., B. of A.E.

Lauer, Earl A., B.S. of Ae.E., Engineer, Cessna Aircraft Co.

Leggee, Richard E., B.Ae.E., Test Engineer, General Electric Co.

Leiner, William W., A.E., Engineer-Draftsman, Steelcraft Mfg. Co.

Lestinsky, Joseph John, A.A. in Ae.E.

Linkous, Guy F., Jr., A.E., Aero. Engineer, The Glenn L. Martin Co.

Locklin, Robert G., B.Aero.E.

Love, Kenneth H., B.A.E., Engineering Draftsman, Consolidated Vultee Aircraft Corp. (Fort Worth).

Marsh, John A., B.S. in A.E., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

Marshall, Andrew R., B.Ae.E.

Martin, Metro, Capt., U.S.A.F.; Procurement, Hq., Res. & Dev. Command.

McConnelly, Rex E., M.S., Designer "B," Douglas Aircraft Co., Inc. (El Segundo).

McLean, George E., B.S. in Ae.E., Senior Detailer, McDonnell Aircraft Corp.

Mele, John A., B.S. in A.E., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

Meyer, H. J., Engineering Draftsman, North American Aviation, Inc.

Miller, Byron D., B.S. in Ae.E.

Montgomery, Robert J., Aero. Engineer, Jr. Engineer "B," Boeing Airplane Co. (Seattle).

Murty, Kenneth T., B.S. in Ae.E., Jr. Engineer, Experimental Liaison Department, Chance Vought Aircraft Div., United Aircraft Corp.

Neal, Thomas E., B.S.E. (Ae.E.), Engineer, Continental Aviation & Engineering Corp.

Newby, R. E., B.S., Pilot, U.S.A.F.

Oehman, Waldo I., B. of M.E. (Aero.).

Outlaw, T. A., Jr., B.S.Ae.E., Student Aid Trainee Serving as Jr. Airframes Engineer, Bureau of Aeronautics, Department of the Navy.

Pates, Raymond E., B. of Ae.E., Engineer, Group Administration, Boeing Airplane Co. (Seattle).

Payne, James D., Major & Sr. Pilot, U.S.A.F.; assigned to Research & Development, Wright-Patterson Air Force Base.

Place, M. Jeanne, B.S.Ae.E., Test Engineer, Aircraft Gas Turbine Div., General Electric Co.

Poletti, Peter J., B.S., Aero. Engineer (Aircraft Design), Grumman Aircraft Engineering Corp.

Rand, Milton L., B.S.Ae.E.

Rinnert, Heinz R., B.S.

Saneto, Satoshi.

Scott, Le Roy S., B. of Ae.E.

Setzko, Joseph F., B. of Ae.E., Jr. Engineer, Stanley Aviation Corp.

Shinosaki, Gene, B.S.

Simkovich, Edward A., B. of Ae.E., Jr. Test Engineer, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Smith, Alexander A., Jr., B.S., Draftsman, Naval Air Station (Norfolk, Va.).

Smith, Edward L., Production Supervisor, AirToy Co.

Smith, Harlan E., B. of Ae.E., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

Smith, Robert E., Engineering Drafts man, Cessna Aircraft Co.

Snow, John E., B. of M.E., Engineer & Pilot, U.S.A.F.

Stearns, Frank R., B.M.E., Jr. Structures Engineer, Chase Aircraft Co., Inc.

Stegemeier, Jack C., B.S., Engineering Draftsman, Douglas Aircraft Co., Inc. (El Segundo).

Striho, Helen C., B.S.E. (Aero.), Administrative Asst., Cornell Aero. Lab., Inc.

Stuart, William C., Mathematician, Structures Group, North American Aviation, Inc.

Tate, Roger E., B.S., Research Laboratory Analyst, Consolidated Vultee Aircraft Corp.

Thomas, John W., B.Ae.E., Flight Inspector, Curtiss-Wright Corp.

Trefny, Richard B., B.Ae.E., Graduate Student, University of Washington.

Victorian, Henry C., B.S.Ae.E., Design Engineer, Cessna Aircraft Co.

Walker, Averil D.

Watson, Thomas E., B.S. in Ae.E., Lab. Testing Technician, AiResearch Mfg. Co.

Whicker, Lester F., B.S. in Ae.E., Teaching Fellow, Applied Mechanics, Virginia Polytechnic Institute.

Wornom, Dewey E., B.S.

Wright, Harold V., B.S., Graduate Student, University of California.

Yap, Kenneth K., B.S. in M.E. (Aero.), Draftsman, Kaiser Engrs. Div., Kaiser Industries, Inc.

Zabinsky, Helen K., B.S.Ae.E., Computer, Dynamics Group, Bell Aircraft Corp.

Aeronautical Reviews (Continued from page 74)

energy equation in von Mises form, and approximating the coefficients in a manner that is most closely correct near the surface. By the use of known transformations, an expression is derived for heat transfer to a surface with arbitrary temperature distribution along it and with a uniform main stream outside it at arbitrary Mach Number. The temperature distribution that is obtained along a surface in the case when heat transfer is balanced entirely by radiation from it gives higher temperatures near the nose and lower temperatures farther back than are found from a theory that assumes the wall temperature uniform and averages the heat-transfer balance.

Water-Borne Aircraft (21)

À Propos des Souffleries à Eau Proposées par M. Sackmann. L. Escande. *Technique et Science Aéronautiques,* No. 2, 1950, pp. 113–118, illus. Discussion of the towing basins designed by L. A. Sackmann.

Wind Tunnels (17)

Souffleries à Grandes Vitesses et à Densité Variable. Georges Dubois. *Technique et Science Aéronautiques,* No. 2, 1950, pp. 83–112, illus. 17 references.

The need of high-speed and variable-density wind tunnels; research on tunnel characteristics to fulfill particular needs; the construction and characteristics of existing designs; and details of the S4 Ch tunnel being planned by O.N.E.R.A.

Effect of Screens in Wide-Angle Diffusers. G. B. Shubauer and W. G. Spangenberg. *U.S., N.A.C.A., Report No. 949,* 1949. 40 pp., illus. 5 references. U.S. Govt. Printing Office, Washington. $0.30.

Books (Continued from page 83)

tional Standards Laboratory, Sydney, in 1944, which received a limited circulation in mimeographed form in 1945. The author goes as far as possible using no mathematics beyond the calculus and includes as little theory as possible. Worked examples are used extensively as illustrations. The four chapters deal with Fundamental Theory, Electric Circuit Theory, Further Theorems and Their Applications, and Partial Differential Equations. The author is a lecturer in mathematics at the University of Tasmania.

PHYSICS

University Physics. Francis Weston Sears and Mark W. Zemansky. Cambridge, Mass., Addison-Wesley Press, Inc., 1949. 848 pp., illus., diagrs. $6.00.

This textbook is designed for use in a two-semester course for students of sciences and engineering who are studying the calculus concurrently. The general scope of the volume includes mechanics, heat, sound, electricity and magnetism, optics, and atomic physics; topics of an intermediate nature are omitted. The calculus is introduced sparingly beginning with Chapter 4 on Rectilinear Motion and is included after that in both text and problems.

The Nature of Physical Theory. P. W. Bridgman. New York, Dover Publications, Inc., 1949. 138 pp. $2.25.

This is a reprint of Dr. Bridgman's classic study of modern scientific theory, originally published in 1936. Operations, thought, language, logic, relativity, wave mechanics, and the mathematical system, including applications, mathematical models, and probability, are among the topics discussed.

STRUCTURES

Strength of Materials. James E. Boyd. Revised by Samuel B. Folk. 5th Ed. New York, McGraw-Hill Book Company, Inc., 1950. 417 pp., diagrs. $4.00.

In this new edition of a standard engineering textbook last revised in 1935, emphasis has been placed on the process of analysis and theoretical fundamentals—for example, in the chapter on deflection by double integration. Integration between limits has been omitted, and Mohr's circle is introduced in Chapter 2 on Shear to prepare the way for its use later in discussions of combined stresses. Special beam topics are placed after the discussion of combined stresses. New material has been added in most chapters, including a number of new problems, bringing the total to more than 1,000. The senior author is Emeritus Professor of Mechanics at the Ohio State University, and Professor Folk is with the same institution.

THERMODYNAMICS

An Introduction to Heat Transfer. M Fishenden and O. A. Saunders. London, New York, Oxford University Press, 1950. 205 pp., diagrs. $3.00.

This textbook is designed for undergraduate engineering students and for others not requiring the more elaborate theoretical treatments of heat transfer. Data have been reduced to simplified forms and numerous illustrative examples are included showing the applications of principles to design problems. Chapter headings are Radiation; Thermal Conduction; Dimensional Analysis of Convection; Relation Between Heat Transfer and Friction; Natural Convection; Forced Convection; Heat Transfer from Condensing Vapours; and Heat Transfer to Boiling Liquids. Tables and conversion factors are included in brief appendixes, and indexes of authors and subjects are provided. About 100 references are included in bibliographies at the ends of chapters. The authors are, respectively, Reader in Applied Heat and Professor of Mechanical Engineering in the University of London at the Imperial College of Science and Technology.

Process Heat Transfer. Donald Q. Kern. New York, McGraw-Hill Book Company, Inc., 1950. 871 pp., diagrs. $8.00.

The purpose of this textbook is to present the engineering fundamentals of heat transfer, using the methods and language of industry, and including practical aspects of the subject as supplementary material. This material includes a number of empirical calculation methods that are new to the literature, but are taken directly from industrial practice. Textbook material that is seldom used in industry is largely omitted. Apparatus calculations are included on heat exchangers, tubular condensers, tubular evaporators, tubular vaporizing exchangers, extended surfaces, direct-contact transfer, and radiant heaters. The author is Director of the Process Engineering Division of the Patterson Foundry and Machine Company and Adjunct Professor of Chemical Engineering at the Polytechnic Institute of Brooklyn.

A POSITIVE SEAL AT ALL ALTITUDES...EVEN AT –65°F!

with

LINEAR PACKINGS

The W. H. Nichols Company required special seals, of utmost dependability, for two rather unusual jobs in this pump. LINEAR "Perfectly Engineered Packings" filled the bill and are giving A-1 performance in a critical operation.

The unit includes one oil pressure pump and five scavenge pumps . . . is used on turbojet engines for lubricating and cooling main shaft bearings and gearbox. Two LINEAR "O" Rings seal the joint between the two sections of the pump housing and further prevent the transfer of fluid from the discharge side of the pump . . . two LINEAR "U" Cups keep the oil in and the air out. They must withstand a variety of temperatures from —65° to +160°F. and pressures ranging from sea level up to 45,000 feet.

Meeting such sealing needs is not uncommon with LINEAR. Thousands of products throughout industry are effectively and efficiently using economical, versatile, precision moulded LINEAR "O" Rings and "U" Cups . . . for a host of sealing applications.

In addition to these successful homogeneous rings, seals of fabric reinforced materials, fluoroethylene polymers, silastics and special synthetic rubbers are available to meet specific requirements.

For individualized attention to your packing problem, design or application, CALL LINEAR!

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILADELPHIA 35, PA.

DESIGNERS AVAILABLE

"CAL-AERO TECH" graduates are immediately useful without break-in...and dependable.

EXPERIENCE

4000 hours on board and in aircraft shops, with fundamentals and actual work assignments under supervision of Aircraft Factory Experienced Designers — specializing in design of component parts — proficient in layout, strength checking and manufacturing process analysis.

New class graduates each month — serving Douglas • North American • Boeing • Northrop • Curtiss-Wright • Lockheed Convair • Ryan • Airesearch • and many others.

HIRE A "CAL-AERO" GRADUATE — HE'LL DELIVER THE GOODS

Phone or write

CAL-AERO TECHNICAL INSTITUTE

Grand Central Air Terminal — Glendale 1, California

ENGINEERS

AIRPLANE & HELICOPTER

Positions available for men with Engineering Degree and experience in airplane or helicopter engineering particularly in:

AERODYNAMICS	STRESS ANALYSIS
DESIGN	FLIGHT TEST ENGINEERING
FLUTTER & VIBRATION	INSTRUMENTATION DESIGN

HANDBOOK WRITERS AND ILLUSTRATORS

Send resume of training and experience, date available, and references.

McDONNELL AIRCRAFT CORPORATION

Post Office Box 516 St. Louis (3), Missouri

PROJECT ENGINEERS

Opportunities Exist for Graduate Engineers with Design and Development exp in any of the following:

ANALOGUE COMPUTERS	SERVO MECHANISMS
RADAR	ELECTRONIC CIRCUITS
COMMUNICATION EQUIPMENT	AIRCRAFT CONTROLS
HYDRAULICS	INSTRUMENTATION
ELECTRONIC PACKAGING	PRINTED CIRCUITS
PULSE TRANSFORMERS	FRACTIONAL H. P. MOTORS

SUBMIT RESUME TO EMPLOYMENT DEPT.

SPERRY

GYROSCOPE CO.

DIVISION OF THE SPERRY CORP.

GREAT NECK, L. I., NEW YORK

Aircraft Engineering

FOUNDED 1929

The Technical and Scientific Aeronautical Monthly

Edited by Lt.-Col. W. Lockwood Marsh

F.I.Ae.S., M.S.A.E., F.R.Ae.S.

Single Copies: 35 cents, post free

Subscription: $5.00 per annum, post free

BUNHILL PUBLICATIONS LIMITED

12 Bloomsbury Square London : : W.C.1 England

Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to Aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

Wanted

Design Engineers—Air-borne, electromechanical equipment design for development and production. **Project Engineers**—Proven design and supervision experience, some aircraft. Graduates preferred. Five-year minimum experience. **Mechanical**—Lightweight complex electromechanical. **Servomechanism**—Specialist; electromechanical and hydraulic. **Microwave Specialist**—Theoretical and design. **Electronic**—Amplifiers, low-frequency test equipment, General circuits. Prototype to production. **Design Engineers**—Mechanical. Three years' minimum experience. Submit complete brief of experience, education, etc. List complete addresses of employers, supervisor references, actual earnings, etc. Address: Chief Engineer, Dalmo Victor Company, San Carlos, Calif.

Thermodynamicist—Advanced training with Master's or Doctor's degree. Aeronautical experience desirable. **Structures Engineer**—Aeronautical degree with at least 3 or 4 years' aircraft experience in structural analysis. Civil Engineers with similar experience will also be considered. **Weights Engineer**—Technical graduate, considerable experience in preliminary design in connection with weights work. Should possess estimating ability. **Senior Development Engineers**—Group Leader; educational background physics, or electrical, or mechanical engineering. Applicable experience in such fields as gyros, servos, intricate machine design, mechanics, or dynamics. Technical ability is of foremost importance. **Helicopter Engineers**—(A) Mechanical Engineers experienced in engine work, helicopter design, or aircraft control systems. (B) Aeronautical or Structural Engineers with a degree plus 4 to 5 years' experience in sheet-metal construction. (C) Electrical Installation Engineer with a college degree or equivalent, 2 to 3 years' experience in actual installation design work. NOTE: Profound interest in the designing and building of helicopters is essential for these positions. **Chief, Systems Test Engineer**—Technical graduate; at least 3 to 5 years of experience including various types of systems test; 60 per cent electronics and related experience such as instrumentation work, leadership ability essential. **Test Engineers—Missiles**—Electronics or Radio Engineering degree or equivalent with considerable experience in electronic circuitry. **Senior Dynamics Engineer**—A Master's or Doctor's degree in applied mathematics or physics, or aeronautical engineering with emphasis in dynamics and vibrations. Some experience in servomechanisms, flutter and vibrations, or stability desirable. Position also available for Electronics Engineer with mathematical ability and interest in dynamics work. **Research Dynamicist**—Advanced education in applied mathematics with experience in operations research. Include a comprehensive résumé with each inquiry, and address all replies to: R. C. Marks, Manager, Engineering Personnel, Bell Aircraft Corporation, P. O. Box 1, Buffalo 5, N.Y.

Aerodynamics Engineer—M.S. degree, theoretical knowledge, and practical experience with high-speed aerodynamic design, performance, and dynamic stability problems. These qualities, plus the capacity for original thinking, are required to become an associate in a firm concerned only with research and development work. Send résumé to Van Zelm Associates, 28 E. 21st St., Baltimore 18, Md.

Engineering & Physicists—Higher degrees preferred. Several years' experience in analysis and design in the following fields: electronic circuits—pulse networks, video amplifiers, timers, triggers. Magnetic recording—magnetic and associated electronic circuits. Apply employment office, Northrop Aircraft, Inc., 1001 East Broadway, Hawthorne, Calif.

Senior Electronics Engineers—B.S. or M.S. degree and 3 years' experience in radar, television, pulse, video, or display circuit design. Salary range $375–$535 per month. **Electronics Engineers**—B.S. degree and 2–3 years' experience as noted above for Senior Electronics Engineers. Salary range $325–$430 per month. **Digital Computer Design Engineers and Automatic Telephone Switchboard Design Engineers**—Salary range $480–$639 per month. **Senior Electromechanical Engineers**—Degree and a minimum of 4 years' experience in servomechanisms, analog computers, special weapons, or system design. Salary range $375–$535 per month. Send résumé to Employment Department, The Glenn L. Martin Company, Baltimore 3, Md.

237. Engineer—Experienced aeronautical engineer to teach airplane design courses. Candidate should have B.S. and M.S. (or higher) degrees. Rank and salary are open and would be commensurate to candidate's age, training, and experience.

229. Electronics Engineer or Physicist—To assist in evaluation of missile-guidance systems from operational or user's point of view—high level organization. Location: Washington, D.C. Submit complete résumé and references. Salary dependent on qualifications.

220. Assistant Sales Manager—Expanding market of aircraft instrument manufacturer opens new positions with attractive future available to qualified man. State aviation experience, including sales, engineering, and flying ability; also education and starting salary desired.

Available

243. Engineer—Six and one-half years' experience in aircraft and aircraft control-system dynamics. Specialist in devising and analyzing servo controls for pilotless aircraft. Has directed analog computer studies of autopilot designs.

242. Project Engineer—Specialties in aerodynamics, flight-test, preliminary design, aircraft systems and instrumentation, electrical and electronic control equipment. Presently in top supervisory aerodynamics position. Previous experience as Director of Research, Assistant Chief Engineer, Chief Aerodynamicist, and Assistant Project Engineer. Education, Phi Beta Kappa Physicist. Pilot's license (14 years). Desires more challenging position, preferably of project nature, where proven ability to administer and coordinate technical undertakings can be used more fully. Best of industry and services references. Age 33.

240. Aeronautical Engineer—B.S.Ae.E., Aeronautical University. Desires a junior position in the engineering field. Willing to continue schooling. Spent three years with the U.S.A.A.F. as flight engineer on B-17, B-24, and B-29. Age 26, single. Location open. Available immediately.

238. Aeronautical Design Engineer—B.S.M.E., 1940. Licensed Professional Engineer. Ten years' experience with large aircraft company. Seven years in aircraft landing gear, hydraulic system, and heating and ventilating system design, including three years as group supervisor. Three years in fluid systems and structural design for guided missiles. Desires design or project position, preferably in guided-missile field.

236. Lawyer—Engineer—B.Sc. in Aeronautical Engineering from Iowa State College; LL.B. from University of Nebraska. Age 26. Member of the Nebraska Bar; currently studying for the California Bar. Two years' law-enforcement experience; one year's experience in stress analysis for large aircraft manufacturer. Willing to locate anywhere in the U.S.A. but prefers West Coast.

235. Writer—Technical, editorial. Graduate Aeronautical Engineer seeks staff connection with aviation periodical. At present connected with flight-test department of major air-frame manufacturer. Good contacts. Single, free to travel.

234. Teacher—Desires position as Assistant Professor or Associate Professor of Aeronautical Engineering or Engineering Mechanics at recognized college or university. B.Ae.E. degree, magna cum laude. M.S. in Ae.E. Three years of progressively responsible industrial experience, including stress analysis and design of tubular and stressed-skin structures and of the mechanical elements of civilian and military aircraft with emphasis in rotary-wing field. Over 4 years of college teaching experience as instructor and assistant professor. Qualified to teach graduate courses in theory of elasticity and elastic stability, experimental stress analysis, rotary-wing aerodynamics, etc., as well as undergraduate curriculum in aerodynamics, aircraft structures, and airplane design. In reply please discuss rank available and salary schedule.

233. Aeronautical Engineer—Graduate. Twenty years of well-rounded experience with several leading aircraft manufacturers and the U.S. Navy. Design supervisory and organizational background. Military and commercial aircraft

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

GRADUATE MECHANICAL ENGINEERS, CHEMICAL ENGINEERS, or PHYSICISTS for research design and development work on rockets, rocket components and guided missiles. Firm academic background in mathematics, hydraulics, thermo-dynamics and stress analysis necessary. Experienced in the field of rocketry or allied work. Advanced degree desirable.

Applicant must furnish transcripts of academic record, names of four persons familiar with research ability, complete resume of past experience and salary desired. All correspondence will be kept confidential.

AEROJET ENGINEERING CORPORATION

P. O. Box 296, Azusa, California

FOUNDATIONS of AERODYNAMICS

By A. M. KUETHE *and* J. D. SCHETZER; *both at the University of Michigan.*

This new book covers all three divisions of the subject: Subsonic fluid mechanics, Compressible flow, Viscous flow. Building from first principles, it gives concepts that may be used in the application of aerodynamics to problems in aeronautics and other fields of engineering.

FEATURING:

1. **One terminology, one approach applied to all three divisions of aerodynamics**
2. **Complete treatment—develops the subject from the ground up**
3. **Experimental results given for comparison with theory—shows where theory falls short of facts**
4. **Classical foundations, modern developments both included**

1950 374 pages
213 illus. $5.75

EXAMINE THIS BOOK 10 DAYS—NO OBLIGATION

APPROVAL COUPON

John Wiley & Sons, Inc., Dept. AE-1150
440 Fourth Ave., New York 16, N. Y.

On 10 days' approval, send me *Foundations of Aerodynamics*. I will remit $5.75 plus postage or return book postpaid. (Offer not valid outside U. S.)

Name.....
Address.....
City.....Zone....State.....

SAVE POSTAGE. We pay postage if you enclose $5.75 now. Money back on same return privilege.

and guided missiles. Desires responsible position. Willing to travel.

231. Aeronautical Engineer—Age 25. Graduate of Parks College of Aero. Tech., 1948. Over 2 years of drafting experience in detail and layout. Now employed in South; desires a permanent position with opportunities in Middle Atlantic States area. Has A.A.F. and A.E.C. security clearance. Desires position as layout draftsman or junior engineer in air frames or jet engines and components.

230. Aeronautical Engineer—B.S.Ae.E., Aeronautical University of Chicago, 1949. Desires opportunity in design and research in the field of rocket and jet propulsion or instrumentation (servomechanisms, automatic controls, etc.). Capable technical report writer and researcher. Proficient draftsman. Machine-shop and drafting experience, including design and stress analysis. One year's experience as navigation and instrument instructor in service. Three years in Air Forces. Good scholastic record and willing to continue education. Age 27, location open.

228. Aeronautical Engineer—Doctor of Engineering. Experience of 23 years includes aircraft detail design; development; design and preliminary stress analysis of structural, mechanical; and hydraulic components of aircraft; preliminary design; design of complete commercial and military aircraft; flight testing; air-line engineering and maintenance; and considerable shop experience. Has conducted Airplane Design Course at eastern college. Desires responsible position in research, development, or design organization.

227. Engineer-Instructor—B. Aero. E., M. Aero. E., Professional Engineer. Two years of aerodynamics in stability and control, performance, air loads, wind tunnel. One and one-half years as research engineer with precision instrument firm on East Coast. Experience includes precision experimental instrument design and test, purchasing, shop liaison. Now finishing second annual contract as Instructor in Aeronautical Engineering in New England College. Would prefer Assistant Professorship in New York or New England area or responsible industrial position. Will relocate if attractive. Full knowledge of present employer.

226. Aeronautical Engineer—B.S. in Aeronautical Engineering (M.I.T.), A.E. (N.Y.U. Engineering College). Eleven years' experience in airplane manufacturing plants and air lines doing engineering research, aerodynamics and structural design—i.e., sonic and supersonic airplane performance and stability; air loads; servomechanism design; stress analysis, etc. Adept at solving problems requiring ingenuity, originality, and the application of engineering principles, mathematics, and physics. Licensed Mechanical Engineer No. 8587 with the California Board of Registration for Civil and Professional Engineers. Five years' high-school teaching experience in mathematics and sciences. Adult Education Credential No. Q 1 6572 for teaching mathematics and social studies in the State of California. Desires responsible position with research or development organization in or near an educational institution where a Doctorate in Mathematics and Physics may be obtained. Would be interested in teaching supplemented with research.

225. Aeronautical Engineer—Nine years' experience. In airplane manufacture, 3 years covering shop liaison, design of aircraft equipment, and supervision of preparation of technical publications. In air lines, 4½ years in service

GRADUATE PHYSICAL ORGANIC AND INORGANIC CHEMISTS. Ph D. required. Men with firm academic background and industrial experience for research and development work in the field of liquid and solid propellants. Should have knowledge of kinetics, thermo-chemical measurements, high-polymers, interior ballistics, resins and nitro-compounds. Firm background of mathematics, plus the ability and desire for both group and independent research.

Applicant must furnish transcripts of academic record, names of four persons familiar with research ability, complete resume of past experience and salary desired. All correspondence will be kept confidential.

AEROJET ENGINEERING CORPORATION

P. O. Box 296, Azusa, California

ENGINEERS NEEDED IMMEDIATELY

Men with aircraft experience are needed in the Engineering Department of Chance Vought Aircraft, Dallas, Texas, for work in the following classifications:

AERODYNAMIC ENGINEERS
STRUCTURAL DESIGN ENGINEERS
FLUTTER AND VIBRATIONS ENGINEERS
ANTENNAE DESIGN ENGINEERS
DESIGN DRAFTSMEN
CASTING AND FORGINGS ENGINEERS
POWER PLANT ANALYSTS
ELECTRONIC DEVELOPMENT ENGINEERS
AIRCRAFT INSTRUMENTATION ENGINEERS
STRUCTURAL TEST ENGINEERS
TECHNICAL ILLUSTRATORS
TECHNICAL WRITERS
HYDRAULIC TEST ENGINEERS
WEIGHTS ENGINEERS

Send resume of training and experience to

Engineering Personnel

CHANCE VOUGHT AIRCRAFT

Box 5907, DALLAS, TEXAS

AIRSURANCE

Airline Passenger Insurance

Annual Policies from $5,000 to $100,000 at new low rates

No Physical Examination • No Age Limit

EXAMPLE
$25,000.00 for death or dismemberment
$1,000.00 for Hospital and Doctor's bills
$50.00 per week when disabled
PREMIUM $38.00 per year

Policies cover all airlines in U. S. and American Flag lines world-wide — also airlines in Canada, Mexico and South America which meet safe operating standards.

Backed by the Combined Assets of

Aetna Casualty & Surety Co.
American Surety Co. of N. Y.
Century Indemnity Company
Hartford Accident & Indemnity Co.
Maryland Casualty Co.
Massachusetts Bonding & Insurance Co.
New Amsterdam Casualty Co.
Standard Accident Insurance Company
Travelers Indemnity Co.
United States Fidelity & Guaranty Co.

U.S. GROUP

WRITE OR PHONE ANY U S GROUP OFFICE

UNITED STATES AVIATION UNDERWRITERS
INCORPORATED
80 JOHN ST. • NEW YORK 7, N. Y.
WASHINGTON ATLANTA CHICAGO LOS ANGELES

AN INVITATION TO

Aircraft Engineers

FROM **LOCKHEED** IN **CALIFORNIA**

Lockheed in California invites you to participate in its long-range production program, developing the aircraft of the future.

Lockheed offers an attractive salary now, a future in aeronautical science, a chance to live and work in Southern California.

Lockheed also offers generous travel allowances to those who qualify.

Lockheed has immediate openings for:

Aircraft Design Engineers
Stress Engineers and Analysts
Draftsmen
Flight Manuals Engineers

Write today — giving full details as to training and experience. Address:

Karl R. Kunze, *Employment Manager*
LOCKHEED Aircraft Corporation
Burbank, California

224. Aeronautical Engineer—B.M.E., 1941. Nine years in the aircraft industry, 2½ years as stress analyst on naval aircraft. Past 6½ years as a flight research engineer. At present directing major flight research project to correlate flight and analytically predicted results. Present duties include specifying conditions of flight tests, data to be recorded, instrumentation, calibrations, flight checks, evaluating flight data, conducting theoretical investigations, coordinating work of specialists on project, consultations, writing reports. Desires position, preferably in East, directing flight research programs, or would act as European representative for organization requiring man with extensive technical aeronautical engineering experience. Details of background furnished on request.

223. Junior Layoutman—Seven years' experience; 5 years in aircraft industry; past 2 years in civil service at Government arsenal doing plant equipment design and drafting. Wishes to return to aircraft. Desires to locate in Northern New York State but will locate anywhere.

222. Aeronautical Engineer—Seventeen years' experience on military aircraft. Specialized in instruments, radio, and equipment. Two years as project engineer on Army liaison plane. Three years as chief draftsman for large aircraft manufacturing corporation. Two years in research, guided missiles, and instrumentation for rocket testing. Interested in position utilizing background of experience to best advantage.

221. Aeronautical or Mechanical Engineer—B.S. Degree in Aeronautical Engineering. Graduate student for 1½ years in Aeronautics and Applied Mechanics. Approximately 3 years in the aircraft industry as a senior draftsman and aerodynamicist. Desires a position in stress analysis or aerodynamics and other related engineering work. Will accept position anywhere in the United States or abroad.

205. Mechanical Engineer—Licensed Professional Engineer. Eleven years' experience: 2 years of teaching evening classes, Washington University, St. Louis, Mo. Supervisory experience includes 3 years as Chief of Design, 1 year as Project Engineer (power plant), 1 year as Group Engineer (power plant), 1 year as Lead Man (power plant and preliminary design). Active Wright Field and BuAer contacts 1943–1945; active C.A.A. Washington contacts 1945–1946. Experienced in preliminary design (8 years), including practical estimations of manpower (shop and engineering) and material costs. Diversified experience ranges from complete airplane and guided-missile design to components, including liquid-oxygen test devices, injector plates, rocket-motor shells, high-speed bearing application, miniature power plants, and optics systems for seekers. Will consider supervisory or administrative work with a small, aggressive, and well-financed group. Currently holds two Professional (P-6) Civil Service Ratings.

FREE! FREE!

Liberal Size Sample of Famous

MOTOR MICA

TRADE MARK REG. U. S. PAT. OFF.

COOLING

ANTI-FRICTION COMPOUND

In White Powdered Form

COOLS HOT BEARINGS QUICKLY

SAVES WEAR ON MOVING PARTS

Find out how Motor Mica can put an end to your lubrication problems. Try it with your cutting oils, in die-casting, deep-drawing, metal stamping, etc. Works wonders in screw machine, punch-press and other operations. Write on your business letterhead for free sample. No obligation.

Keeping the Wheels of Industry Cool Since 1914

SCIENTIFIC LUBRICANTS CO.
3469 N. Clark Street • Chicago 13, Ill.

LOW or HIGH PRESSURE

High pressure or low, there is a Giannini precision pressure transmitter that meets your requirements for remote indication, recording or control.

From less than 1 up to 10,000 psi, with various types of resistance and inductive output values, Giannini precision pressure transmitters are designed to withstand extremes of acceleration, temperature, vibration, while at the same time retaining their accuracy and their fast response characteristics. "They are standard with the Leaders." Write for booklet.

G. M. Giannini & Co., Inc., Pasadena 1, California

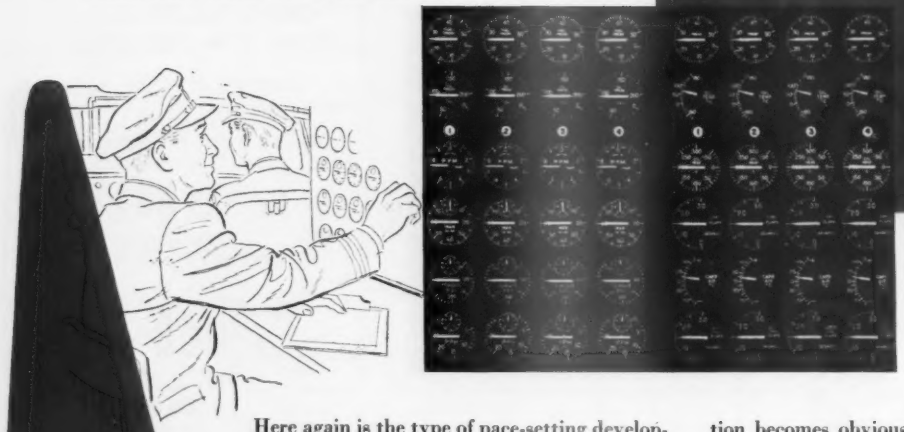
giannini

ENGINEERED ENGINE INDICATORS

ECLIPSE-PIONEER'S

HIGH PRECISION
CLAMP-ON INDICATORS FOR ENGINE FUNCTIONS

NOW AVAILABLE FOR ALL MILITARY AND COMMERCIAL PLANES



Greater Accuracy
Easier to Read
Lighter Weight
Simplified Installation and Maintenance
Conserved Panel Space

Here again is the type of pace-setting development work that has consistently highlighted Eclipse-Pioneer's leadership in this field. Developed in cooperation with the Equipment Laboratory at Wright Field, these new "clamp-on" instruments are built around the famous Eclipse-Pioneer High Precision Autosyn* which inherently assures an exceptionally high degree of accuracy. A further advantage becomes apparent when these instruments are grouped so that all pointers are parallel during normal operation. Experiments with this type of arrangement revealed that entire panels could be read accurately *in a fraction of the time normally required* . . . any abnormal condition becomes obvious immediately when one of the pointers moves out of line. However, for precise readability of critical functions, a servoed indicator with secondary pointer is available in the same small diameter case. Clamp-on instruments are extremely lightweight and offer tremendous savings in installation and maintenance time. A simple bezel attachment will adapt these new Eclipse-Pioneer High Precision engine instruments to the standard AN openings in your present instrument panels. So, write today, get all of the details on this latest product of Eclipse-Pioneer's experience and ingenuity.

*REGISTERED TRADEMARK OF THE BENDIX AVIATION CORPORATION

ECLIPSE-PIONEER DIVISION OF **Bendix** AVIATION CORPORATION

TETERBORO, NEW JERSEY

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N. Y.

Engine Control Equipment • Air Pumps • Engine Starting Equipment • Hydraulic Equipment • Ice Elimination Equipment • Power Supply Generating Equipment • Power Supply Regulating Equipment • Flight Instruments • Automatic Pilots • Flight Path Control Systems • Engine Instruments • Navigation Instruments

LOOK FOR THE PIONEER MARK OF QUALITY

REG. U.S. PAT. OFF.

Index to Advertisers

A

★Aerojet Engineering Corporation 92
Aeronautical Engineering Catalog 79
Aeronautical Engineering Review 79
Aeroproducts Division, General Motors Corporation 69
★Airborne Accessories Corporation 8
AiResearch Manufacturing Company Division, The Garrett Corporation 76
Allegheny Ludlum Steel Corporation 56
Avica Corporation 58

B

B. H. Aircraft Company Inc. 80
Bell Aircraft Corporation 51
★Bendix Aviation Corporation
★Bendix Products Division 87
★Eclipse-Pioneer Division 94
★Scintilla Magneto Division 67, 73
Bunhill Publications Limited 90

C

Cal-Aero Technical Institute 90
Chance Vought Aircraft Division, United Aircraft Corporation 92
Chicago Metal Hose Corporation 17
★Clifford Manufacturing Company Division, Standard-Thomson Corporation 71
★Curtiss-Wright Corporation, Wright Aeronautical Corporation Division 46, 47

D

Douglas Aircraft Company, Inc. 61
Dow Corning Corporation 78

E

★Eclipse-Pioneer Division, Bendix Aviation Corporation .. 94
★Electrical Engineering and Manufacturing Corporation ..... Inside Front Cover
★Electrol, Incorporated 15
A. H. Emery Company, The ..... Inside Back Cover

F

★Fairchild Engine and Airplane Corporation
★Fairchild Aircraft Division 4
Guided Missiles Division 96

G

Garrett Corporation, The, AiResearch Manufacturing Company Division 76
General Motors Corporation, Aeroproducts Division 69
General Radio Company 68
G. M. Giannini & Company, Inc. 93
Goodyear Tire & Rubber Company, Aviation Products Division 1

H

Holley Carburetor Company 2
Industrial Sound Control 8
Imperial Pencil Tracing Cloth, Keuffel & Esser Company . 53
International Nickel Company, Inc, The 48

J

★Jack & Heintz Precision Industries, Inc. 63
Joy Manufacturing Company 11

K

Keuffel & Esser Company, Imperial Pencil Tracing Cloth . 53
Kollsman Instrument Division, Square D Company 81

L

Lamb Electric Company, The 82
G. H. Leland Inc. 14
Linear, Inc. 90
Lockheed Aircraft Corporation 52, 53, 93
Lord Manufacturing Company 50

M

★Marman Products Company, Inc. 88
Glenn L. Martin Company, The 54, 55
McDonnell Aircraft Corporation 90
Miniature Precision Bearings, Inc. 72
Minneapolis-Honeywell Regulator Company .... Back Cover

N

North American Aviation, Inc. 72

P

Pacific Scientific Company 13

R

★Rohr Aircraft Corporation 65

S

Scientific Lubricants Company 93
★Scintilla Magneto Division, Bendix Aviation Corporation 67, 73
Servomechanisms Inc. 50
★Sperry Gyroscope Company, Division of The Sperry Corporation 75, 90
Square D Company, Kollsman Instrument Division 81
★Standard-Thomson Corporation, Clifford Manufacturing Company Division 71
Surface Combustion Corporation, Aircraft-Automotive Division 85

U

United Aircraft Corporation, Chance Vought Aircraft Division 92
United States Aviation Underwriters Incorporated 93

V

Vellumoid Company, The 72

W

John Wiley & Sons, Inc. 92
★Wright Aeronautical Corporation Division, Curtiss-Wright Corporation 46, 47

★ ***Specifications and further information on the aircraft products of these companies will be found in the 1950 AERONAUTICAL ENGINEERING CATALOG***

The only publication of its kind devoted exclusively to the aircraft industry, this CATALOG serves as a valuable buyers' and reference guide to sources and specifications on aircraft materials, parts, and accessories. It is distributed annually to Chief Engineers, Designers, Production Heads, and Purchasing Departments of all leading Aircraft, Aircraft Engine, Instrument, Accessory, and Aircraft Parts Manufacturers; Air Transport Companies; Army, Navy, and Governmental Agencies; Research Organizations; Engineering Libraries; etc.

Published Annually by

INSTITUTE OF THE AERONAUTICAL SCIENCES

2 East 64th Street New York 21, N.Y.

Advanced aerodynamic design is what you expect when a top team of designers like those of the Fairchild Guided Missiles Division build a missile. But that is only part of the problem in missile manufacture.

A guided missile is packed from nose to tail with complex electronic guidance circuits that must control its flight accurately—even during the shock of launching and the high G loads of tight turns. The *avionic brain* must not "black out" even under loads well beyond those a human pilot can withstand.

In Fairchild's missiles, not only the airframe but the complete missile, including the *avionic brains* —that are squeezed into the cramped quarters of the missile's body—are Fairchild designed and Fairchild manufactured.

To prove the ruggedness and reliability each missile is subjected to G loads never before asked of electronic equipment, while test apparatus shows how the "bird" stays locked on the target. Flight tests confirm this amazing accuracy and ruggedness.

Here is another example of Fairchild research and development, at work for the Armed Services.

Far ahead in the field, Fairchild Guided Missiles are an example of the achievement possible when top-flight aerodynamicists and ingenious electronic engineers tackle closely interrelated problems as a single, united team.

ENGINE AND AIRPLANE CORPORATION
FAIRCHILD *Guided Missiles Division*
FARMINGDALE, N. Y.

Other Divisions: Fairchild-NEPA Division, Oak Ridge, Tenn. • **Fairchild Aircraft Division,** Hagerstown, Md.
Fairchild Engine Division, Al-Fin Division and Stratos Corporation, Farmingdale, N. Y.